

56
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1911.

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PROCEEDINGS
OF THE
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.

EXHIBITIONS AND NOTICES.

November 15, 1910.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

THE SECRETARY read the following report on the additions made to the Society's Menagerie during the months of June, July, August, September, and October, 1910:—

JUNE.

The registered additions to the Society's Menagerie during the month of June were 405 in number. Of these 254 were acquired by presentation, 39 by purchase, 18 were received on deposit, 12 in exchange, and 82 were born in the Gardens.

The total number of departures during the month, by death and removals, was 142.

Amongst the additions special attention may be called to the following:—

2 Addra Gazelles (*Gazella ruficollis*) ♂ ♀, new to the Collection, 1 Mountain Oribi (*Ourebia montana*), 1 Sabre-horned Oryx (*Oryx algazel*) ♀, 1 Addax (*Addax nasomaculatus*), 1 Soudan Fennec (*Vulpes famelicus*), 2 Erythrean Zorillas (*Zorilla erythraea*), 1 Dongolan Genet (*Genetta dongolana*), and 2 Banded Mongooses (*Crossarchus fasciatus*), from the Soudan, presented by Gilbert Blaine, Esq., F.Z.S., on June 4th.

1 Addra Gazelle (*Gazella ruficollis*) ♂, new to the Collection, from the Soudan, presented by G. Guy Chetwynd, Esq., F.Z.S., on June 4th.

1 White-spotted Squirrel (*Funisciurus leucostigma*) and 1 Speckled Squirrel (*Sciurus punctatus*), both new to the Collection, 1 Gaboon Viper (*Bitis gabonica*), and 1 Nose-horned Viper (*Bitis nasicornis*), from Dunkwa, Gold Coast, presented by Dr. H. G. F. Spurrell on June 18th.

6 Cocks-of-the-Rock (*Rupicola crocea*), from British Guiana, deposited on June 14th.

1 Red Bird-of-Paradise (*Paradisea rubra*), presented by J. M. Doctor, Esq., on June 11th.

1 Hunstein's Bird-of-Paradise (*Diphyllodes hunsteini*), received in exchange on June 23rd.

1 Short-tailed Parrot (*Pachynus brachyurus*), from the Upper Amazons, presented by H. D. Astley, Esq., F.Z.S., on June 14th.

2 Queen Alexandra's Parrakeets (*Spathopterus alexandrae*), from Western Australia, purchased on June 11th.

2 Condors (*Sarcorhamphus gryphus*), from Chili, presented by the Government of Chili on June 27th.

A collection of Birds, including Tanagers, Sugar-birds, Tinamous, and Conures, from Brazil and Chili, presented by Albert Pam, Esq., F.Z.S., on June 18th and 27th.

A collection of Birds from Venezuela, including various Tanagers, Finches, a Naked-eyed Pigeon (*Columba gymnoptthalma*), and an Orinoco Goose (*Chenalopex jubatus*), presented by Hugo Pam, Esq., on June 21st.

5 Elephantine Tortoises (*Testudo elephantina*), from Aldabra, presented by Edward Mayer, Esq., on June 15th.

JULY.

The registered additions to the Society's Menagerie during the month of July were 327 in number. Of these 124 were acquired by presentation, 16 by purchase, 85 were received on deposit, 15 in exchange, and 87 were born in the Gardens.

The total number of departures during the month, by death and removals, was 189.

Amongst the additions special attention may be called to the following:—

1 Buffon's Kob (*Kobus kob*), from Sierra Leone, presented by J. A. Tinling, Esq., on July 8th.

1 Sing-Sing Waterbuck (*Kobus unctuosus*) and two Harnessed Bushbucks (*Tragelaphus scriptus*), from Gambia, presented by Capt. Sir George Denton, K.C.M.G., F.Z.S., on July 19th.

2 Harnessed Bushbucks (*Tragelaphus scriptus*), 1 Black-tailed Oribi (*Ourebia nigricaudata*), and 1 Crowned Hawk-Eagle (*Spizaetus coronatus*), from French Guiana, presented by Fenwick Owen, Esq., on July 19th.

1 Abyssinian Duiker (*Cephalophus abyssinicus*), from Nigeria, presented by W. A. Clayton, Esq., on July 20th.

2 Black-backed Geese (*Sarcidiornis melanonota*), from India, presented by Lt.-Col. D. C. Phillott, on July 25th.

3 Wattle Peewits (*Lobivanellus lobatus*), 3 Black-tailed Waterhens (*Tribonyx ventralis*), and 1 Tufted Umbre (*Scopus umbretta*), hatched and reared in the Menagerie.

AUGUST.

The registered additions to the Society's Menagerie during the month of August were 200 in number. Of these 105 were acquired by presentation, 15 by purchase, 27 were received on deposit, 29 in exchange, and 24 were born in the Gardens.

The total number of departures during the month, by death and removals, was 181.

Amongst the additions special attention may be called to the following:—

3 Grey Crab-eating Dogs (*Canis griseus*), from the Argentine, presented by Wilfred Smithers, Esq., on August 22nd.

1 Korin Gazelle (*Gazella rufifrons*) ♀, from Senegal, presented by Maxwell Lyte, Esq., on August 2nd.

2 Ross's Plantain-eaters (*Musophaga rossæ*) and 1 Ardesian Hawk (*Cerchneis ardesiacus*), both species new to the Collection, from Uganda, presented by L. M. Seth-Smith, Esq., on August 15th.

3 Pigmy Cormorants (*Phalacrocorax pygmaeus*), from Dobrudschä, Roumania, presented by the Hon. N. C. Rothschild, F.Z.S., on August 25th.

A collection of Birds, including 2 Rough-billed Pelicans (*Pelecanus trachyrhynchus*), 2 Roseate Spoonbills (*Ajaja rosea*), and 3 American Darters (*Plotus ankinga*), received in exchange from the Zoological Society of Washington on August 23rd.

1 Green Tree-Snake (*Dendraspis viridis*), 1 Kirtland's Tree-Snake (*Thelotornis kirtlandii*), and 1 Banded Gecko (*Hemidactylus fasciatus*), all new to the Collection, from the Gold Coast, presented by Dr. H. G. F. Spurrell on August 21st.

SEPTEMBER.

The registered additions to the Society's Menagerie during the month of September were 228 in number. Of these 37 were acquired by presentation, 81 by purchase, 47 were received on deposit, 53 in exchange, and 10 were born in the Gardens.

The total number of departures during the month, by death and removals, was 210.

Amongst the additions special attention may be called to the following:—

1 Brown Bear (*Ursus arctos beringianus*), from Kamschatka, presented by W. S. Race, Esq., on Sept. 30th.

4 Javan Mouse-Deer (*Tragulid javanicus*), from Java, purchased on Sept. 26th.

1 White-naped Roller (*Coracias naevius*), from the Gambia, new to the Collection, deposited on Sept. 15th.

1 Red-collared Lorikeet (*Trichoglossus rubritorques*), bred in the Menagerie.

1 White-winged Wood-Duck (*Asarcornis scutulatus*), from Burma, new to the Collection, presented by Major H. H. Harington, F.Z.S., on Sept. 12th.

A collection of Snakes containing, amongst others, 6 Indian Cobras (*Naia tripudians*), 2 Banded Kraits (*Bungarus fasciatus*), and 4 Russell's Vipers (*Vipera russelli*), received in exchange on Sept. 10th.

OCTOBER.

The registered additions to the Society's Menagerie during the month of October were 202 in number. Of these 102 were acquired by presentation, 26 by purchase, 47 were received on deposit, 21 in exchange, and 6 were born in the Gardens.

The total number of departures during the month, by death and removals, was 225.

Amongst the additions special attention may be called to the following:—

1 Siamang Gibbon (*Symphalangus syndactylus*), from Sumatra, deposited on Oct. 26th.

1 African Cheetah (*Cynælurus jubatus*), from Andamowa, German Cameroons, presented by Walter Watts, Esq., on Oct. 22nd.

2 Indian Buffaloes (*Bubalus buffelus*), from India, received in exchange on Oct. 15th.

2 Giant Bustards (*Eupodotis kori*), from P. W. J. Le Roux, Esq., a Black-breasted Harrier-Eagle (*Circaëtus pectoralis*), from Crossland Robinson, Esq., and a Stanley Crane (*Anthropoides paradisea*), from Dr. Robert Broom, C.M.Z.S., all presented to the King's South-African Collection through Dr. L. Péringuey, F.Z.S., Secretary of the South-African Presentation Committee, and deposited in the Gardens on Oct. 1st.

A collection of Birds from Venezuela, presented by Hugo Pam, Esq., on October 11th, containing a Bare-faced Hangnest (*Gymnomystax melanicterus*), a Chimachima Milvago (*Milvago chimachima*), a Violaceous Night-Heron (*Nycticorax violaceus*), 3 Naked-eyed Pigeons (*Columba gymnophthalma*), and others.

5 Jackson's Whydah-birds (*Drepanoplectes jacksoni*) and 2 Crimson-ringed Whydah-birds (*Penthetria laticauda*), from East Africa, new to the Collection, presented by Mrs. George Style on Oct. 22nd.

Mr. R. I. POOCK, F.L.S., F.Z.S., exhibited a living specimen of the Black Rat (*Mus rattus*) from Sark, which had recently been presented to the Society's Menagerie by Mrs. C. Russell.

Mr. R. I. Pocock also exhibited a female hybrid, bred in the Society's Gardens, between a male Black Lemur (*Lemur macaco*) and a female of the Red-fronted variety of the Fulvous Lemur (*Lemur fulvus rufifrons*), and pointed out that the offspring resembled neither of its parents. It had not inherited the facial fringe of its father nor the white over the eyes and on the forehead of its mother, this area of the head being dark ashy black with a deeper tinted central line, more approaching the colour seen in the Black-fronted variety of the Fulvous Lemur (*L. fulvus nigrifrons*).

The Hon. N. CHARLES ROTHSCHILD, M.A., F.Z.S., exhibited the following species of Fleas, which were of interest in connection with the spreading of plague by these insects:—*Pulex irritans*, *Xenopsylla cheopis*, *Ctenocephalus canis*, *C. felis*, *Ceratophyllus fasciatus*, *C. londiniensis*, *Ctenopsylla mayardi*.

Mr. J. LEWIS BOXHOTE, M.A., F.L.S., F.Z.S., exhibited in spirit a young Cairo Spiny Mouse (*Acomys cahirinus*) about 12 hours old, and pointed out the advanced state of the young at birth as compared with the common House-Mouse and other species of the genus *Mus*.

In *Acomys* the young at birth were of a pale slate-colour and sparsely covered on the upper parts with downy hairs 2 to 3 mm. in length. Across the lower part of the back the spines could be distinctly felt.

In spite of this advanced development the period of gestation was only 11 days at the most. In the case under notice the male was introduced at 7 P.M. on 19th July and the young were born between midnight and 9 A.M. on the 31st July, a maximum period of 11 days and 14 hours. The period in the House-Mouse was about 13 days. In *Acomys* the usual number in a litter was three; four were exceptional, but two were not uncommon.

In correlation with their forward development the young were also very large at birth, as a comparison of measurements of the individual exhibited and the average measurements of an adult male show:—

	Young 12 hours old.	Ad. ♂.	
Head and body ...	51 mm.	101 mm.	about $\frac{1}{2}$ full size.
Tail	35 mm.	105 mm.	" $\frac{1}{3}$ " "
Hind foot	14 mm.	18 mm.	" $\frac{3}{4}$ " "
Ear	8 mm.	17 mm.	" $\frac{1}{2}$ " "

When 8 to 10 days old the young were able to take care of themselves, and on the fourth day after birth their eyes were open and they occasionally left the nest and ran about the cage.

They bred at a very early age, and by the agency of a young male born on the 4th June progeny were produced on the 31st July, so that it must have bred when only 46 days old.

Mr. Bonhote further stated that among Sand-Rats of the genus *Meriones*, a considerable number of which he had bred this year, the period of gestation was at least 17 days, and the young, which were born quite naked, looked after themselves in about three weeks, five being the usual number in a litter.

Mr. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., exhibited a pair of hybrids between the Bramble-Finch (*Fringilla montifringilla*) and the Chaffinch (*Fringilla caelebs*). This cross had been bred for the first time in 1907 by a lady in Kent, who had since bred several every year.

Mr. Allen Silver, a well-known fancier, first called Mr. Bonhote's attention to these birds. He wrote:—"The young in nestling plumage chiefly resemble a nestling Chaffinch, but show traces of the white rump.

"Males from the cross in which the Brambling was the cock are in every case more brilliant and richer in tone, and exhibit a marked Bramble-Finch form of head, more so than the cross in which the Chaffinch was the male parent. The heads of the males in this latter cross (Chaffinch ♂ and Brambling ♀) are less speckled and almost even in tone of colour, showing few signs of the dark bases to the feathers on the head and having more of a Chaffinch shape."

The cock exhibited resembled a Bramble-Finch on the head, rump, tail, and vent, but on the mantle and breast the colour showed a mixture of the two species; the tail also showed more white than was usually found in a pure-bred Bramble-Finch.

A peculiar feature of this bird was a slight "peak" crest, which had not appeared in any of the other specimens. It seemed to be caused by the long feathers of the nape (a Bramble-Finch feature) meeting the long feathers of the crown (a Chaffinch feature).

One other male of this cross that Mr. Bonhote had seen closely resembled a hen Bramble-Finch.

The hen bird exhibited showed the Chaffinch blood more clearly, her only Bramble-Finch features being the two parallel stripes on the nape, the partially white rump, traces of yellow on the wing-bars, and a more yellowish tint on the breast. The fertility of the hybrids had not yet been tested.

Mrs. R. HAIG THOMAS, F.Z.S., exhibited a series of skins illustrating an experiment in Pheasant-breeding, and gave the following account of the production of *Thaumalea obscura* in the F₂ generation from a cross between *Thaumalea amhersti* ♀ and *T. picta* ♂:—

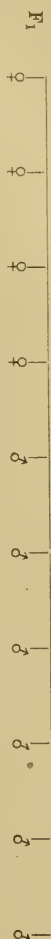
"The skins of the birds used in this experiment are exhibited together with their pedigree (see page 7). An Amherst cock is placed with these skins to show the plumage, but the bird took no part in the experiment.

Purchased from Jarrach, 1905, one *Thaumalea amhersti* ♀.
Purchased from Mrs. Adair Campbell, Ardleigh, Cardross,
1906, two *Thaumalea amhersti* ♀.

Purchased from Col. Middleton, The Chase, Herefordshire,
1906, one *Thaumalea picta* ♂.

Mating 1907.

3 *Thaumalea amhersti* ♀ × *Thaumalea picta* ♂.



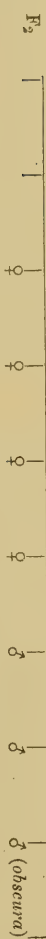
Matings 1909 in two pens.

Cream | Russet | dark Brown (*obscura*)
4 5 2 (♀)

Thaumalea obscura
produced in F₂
from both pens.

F₁ ♀ × F₁ ♂ | 49 eggs, 29 infertile, 20 hatched | F₁ ♀ × F₁ ♂
9 of these F₂ birds reared.

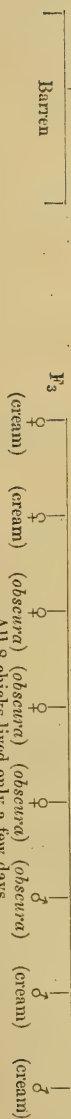
F₂ dead chicks 11 → 4



Matings 1910 in two pens.

F₂ ♀ × F₂ ♂ (*semi-obscura*).

F₂ ♀ × F₂ ♂ (*obscura*).



Summary of F₃ Colours { Cream | dark Brown (*obscura*)
4 4

All 8 chicks lived only a few days.

"In Elliot's 'Phasianidæ' is a coloured plate of a pair of *Thaumalea obscura* with their young, which were considered by him and some other ornithologists as a variety of *picta*; according to this plate the birds apparently bred true.

"In my pheasantry in 1907, three Amherst hens were mated with a Golden cock and produced a number of young called F_1 in the pedigree. In 1909 two pairs of these F_1 birds were mated, and from these two pens 20 F_2 chicks were hatched. Amongst them were three chicks of a deep chocolate-brown, in startling contrast to the others, which were cream-colour with a bronzing of russet on the back and throat. The down of these *obscura* chicks was of a uniform dark brown to the skin, and each eye was rimmed with a finely pencilled cream line, which was connected by another cream line across the top of the bill, giving the quaint appearance of a pair of spectacles; there was also a cream patch on the throat, varying in size in each individual, sometimes being a mere spot. The legs were a dull olive-brown. These brown chicks were produced from both pens, and were of both sexes, but unfortunately only one of the three (a cock) was reared. *Thaumalea* birds attain adult plumage only in the second year, so it was not till July this year that my surmise that *obscura* had been produced was confirmed. The cock has the same barred tail (pattern Amherst, coloration Golden), and the same dark brown on head and throat and neck, as the bird depicted on Elliot's plate, but his breast is a duskier red and the crest and mantle paler. When a chick, his coloration was similar to the young shown on Elliot's plate, only the brown was a deeper, richer shade. This F_2 cock was mated in the spring of 1910 with two F_2 hens, his sisters. The darkest hens were picked out, with Golden eye-skin (yellow with red round the rim); Amherst hens are lighter and greyer in plumage than the Golden, and the eye-skin is a greenish blue. From this mating eight birds were hatched, four cream-coloured and four dark brown chicks; these last had precisely the same coloration as that of the father. The numbers tally with those to be expected according to Mendel's law. I hope to obtain more evidence next season from the same birds, and to have better luck, for all these eight chicks lived only a few days. As I intend to breed again from him, I cannot show you the skin of the adult *obscura* cock, but only some feathers plucked from his breast and back, and the skins of his two brothers and of two of his sisters. An examination of these breast-feathers plucked from *obscura* and of some of the breast-feathers of the cock marked 'semi-*obscura*' will show the reason of the so-called 'duskiness' of hue; each feather has a bar of metallic green on the inner half, while the outer end of it is red. You will observe in the Golden cock that the breast-feather is red throughout.

"Apparently, then, *Thaumalea obscura* is a hybrid recessive mutation, breeding true, as shewn in Elliot's plate and also in my experiment this year, according to Mendel's law. I have used the word 'mutation,' but these birds may possibly be a reversion to the ancestral parent form of both "species" of *Thaumalea*.

"By whatever name it is called, this hybrid is undoubtedly a homozygote for pattern and colour, pure and permanent, transmitting these characters to its descendants. Cross-breeding between these two varieties of *Thaumalea* produces a new form, owing possibly to the meeting of characters never previously combined, and as they are constant it is evident these have an affinity and have become inseparable.

"On such lines Evolution might be conceived as having proceeded fairly rapidly towards the separation of species.

"Some while ago I showed a hybrid hen whose pure Swinhoe plumage had been transmitted through the cock. To-day the skin of her son, a pure Swinhoe cock, is exhibited for your inspection.

"An account of my method and management of these Pheasant-breeding experiments has been already published in the 'Proceedings' (1909, p. 885), showing the care and precautions used."

Two Species of Cysticeroids from the Rat-flea (Ceratophyllus fasciatus).

(Text-figures 1 & 2.)

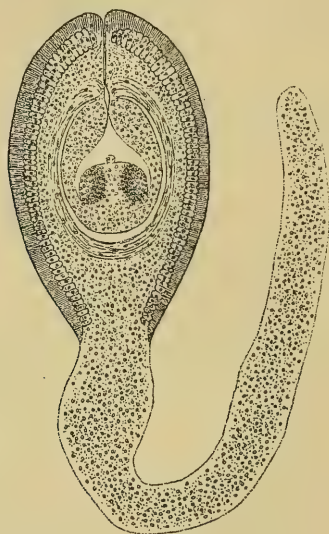
Dr. W. NICOLL and Professor E. A. MINCHIN, M.A., V.P.Z.S., exhibited examples of two species of Cysticeroids which had been found in the body-cavity of the rat-flea (*Ceratophyllus fasciatus*) dissected by Professor Minchin in the course of investigations upon the development of *Trypanosoma lewisi* in the flea.

The first specimen shown (text-fig. 1) was one previously exhibited by Prof. Minchin (P. Z. S. 1909, p. 741). Since then experiments had been carried on by Dr. Nicoll at the Lister Institute, which proved that it was the larval form of *Hymenolepis diminuta*, and threw light upon the mode of infection. This Cysticeroid had occurred in about four per cent. (8 in 207) of all the fleas examined during a period of thirteen months. It was found in the body-cavity and usually only one specimen at a time. As many as three, however, had been found in one flea.

In the retracted state the Cysticeroid consisted of a flattened oval body and a more or less elongated tail. The dimensions of the body were $\cdot 31 \times \cdot 25$ mm., and the tail might be as much as $\cdot 8$ mm. long. The wall of the body consisted of a number of well-differentiated layers. The outermost layer was non-cellular and bore a certain resemblance to cuticle. It was marked by fine radial striations. The second layer consisted of columnar cells, each with a large and distinct nucleus. Neither of these layers occurred in the tail. The third layer was parenchymatous, consisting of a large number of irregularly disposed cells. This was continuous with the substance of the tail. The next layer was apparently of a fibrous nature, consisting of a few cells set in a mass of circularly arranged fibres. This layer was separated from the next by an intervening space. This was seen usually

only as a narrow fissure. It represented the very much reduced vesicle, and separated the main part of the body from the part which was eventually evaginated to form the head of the tapeworm. Internal to this was another layer of loose parenchyma, which at the posterior pole merged into the tissue of the scolex. The latter was extremely small ($\cdot 075 \times \cdot 09$ mm.). On it there were four small circular suckers (diam. $\cdot 055$ mm.) and a small unarmed rostellum.

Text-fig. 1.

Cysticeroid of *Hymenolepis diminuta*. $\times 125$.

This description tallied almost exactly with that of Grassi and Rovelli (Atti Acc. Gioenia Sc. Nat. Catania, iv. 1892, pp. 31-33, pl. iv. fig. 3). They found a corresponding Cysticeroid in the beetles *Akis spinosa* and *Scaurus striatus*, in *Anisolabis annulipes* and in the larva of *Asopia farinalis*. By feeding experiments with Cysticeroids derived from the first of these, they were able to produce infection in a man, and the tapeworm which was recovered was *Hymenolepis diminuta* Rud. (= *Tænia leptocephala* Creplin).

It was recognized that the Cysticeroid from the rat-flea was very probably the larva of *Hymenolepis diminuta*, but that could not be definitely stated without further information, for two other rat-tapeworms (*H. relicta* Zschokke and *H. horrida* v. Linstow) are known, closely resembling *H. diminuta* and probably possessing larvæ almost indistinguishable from that of *H. diminuta*. On that account, in order to establish the identity of the Cysticeroid, a series of feeding experiments was undertaken.

For this purpose a litter of young rats was separated from their mother as early as possible and isolated. They were fed entirely on boiled bread and milk. They were kept under observation for three months, during which time frequent examination of their faeces showed that they were free from tapeworms. Two of the rats were then fed daily with the fleas, which were mashed up in their food. This was continued for 19 days, feeding being omitted on three of these, when one of the rats died. During this period the faeces were examined regularly, but no ova were found. On examining the dead rat, five specimens of *Hymenolepis diminuta* were found in the intestine. They were of various sizes, the largest being over 40 cm. long and the smallest only 1 cm. Next day numerous ova were found in the faeces of the other rat. From this it was evident that the complete development of *Hymenolepis diminuta* took place in less than three weeks. Grassi and Rovelli found ova after 15 days, which was probably about the actual length of time required. The remaining rats of the litter were kept under observation for a further period of two months, but during that time no ova were found in the faeces of any of them. The same experiment was repeated later with a similar result, ova appearing in the faeces on the 19th day. The rat which survived the first experiment was eventually killed and nine tapeworms were removed from its intestine. A total of 14 tapeworms was therefore produced from the 340 fleas with which the rats had been fed. This indicates that about four per cent. of the fleas contained Cysticeroids, and the result agrees with the number of Cysticeroids found in fleas which were actually dissected.

The supposition, put forward in the previous communication, that the flea becomes infected in its larval state, had to some extent been confirmed. The intact ova of *Hymenolepis diminuta* were found in the intestines of 2 larvæ out of 145 examined. No stages in the development of the Cysticeroid, however, had been yet met with in the larval flea. On the other hand, a very young Cysticeroid had been found in the body-cavity of one out of a dozen pupæ examined. The presumption was that it was only the oldest and largest flea-larvæ that were capable of ingesting the tapeworm eggs and that no development took place until the beginning of the pupal stage.

The second Cysticeroid (text-fig. 2, p. 12) was of much greater interest than the first. Hitherto only a single specimen had been met with, and it occurred in the body-cavity of a male *Ceratophyllus fasciatus*. It was considerably smaller than the first Cysticeroid, and like it consisted of an oval body and a tail. The former was .16 mm. long and the latter .19 mm. The two outermost layers of the body-wall were the same as before, but the parenchymatous and fibrous layers were not so sharply differentiated from each other. The scolex, again, was very much larger (diam. .096 mm.) and it had a rostellum armed with a single row of spines, 23 in number. The length of each spine was

·017 mm., the handle being ·01 mm. and the guard ·007 mm. long. The prong was of the same length as the guard. There were four well-formed suckers, which had been pressed into a somewhat crescentic shape (greatest diameter ·042 mm.).

Text-fig. 2.

Cysticeroid of *Hymenolepis murina*. $\times 250$.a. Rostellar spine in full lateral view. $\times 600$.

b. The same, somewhat tilted.

Besides the two Cysticeroids described here and the well-known Cysticeroid of *Dipylidium caninum* from the dog-flea and human flea, there was only one other instance on record of a Cysticeroid being found in a flea. This observation was made a few months ago by Dampf (Centralbl. f. Bakt. etc. 1te Abth. Orig. liv. pp. 452-4), who found in a new species of flea *Mesopsylla eucta* from the jerboa (*Alactaga jaculus*) a Cysticeroid bearing a close resemblance to the second of those described here. Dampf was obliged to make his examination from a mounted (type) specimen of the flea, and on that account could not be certain of some of the details, as, for instance, the exact number of the spines and the presence of a tail. So far as he could make out, there were from

20 to 24 spines. Lühe, to whom the specimen was referred, mentioned the supposition that the Cysticercoid might be that of *Hymenolepis nana* (v. Sieb.).

From the description given of the second Cysticercoid it was apparent that it was very like the scolex of *Hymenolepis murina* Duj., a frequent parasite of various species of rats. The size of the scolex of the Cysticercoid, the arrangement, number, size, and shape of the spines all agreed with those of *Hymenolepis murina*, and it was certainly the only rat-tapeworm to which the Cysticercoid could be referred. The closely allied *Hymenolepis microstoma* Duj. had 30 spines of much smaller size. *H. contracta* Janicki and *H. muris variegati* Janicki, neither of which corresponded to the Cysticercoid, were the only other armed Hymenolepids found in rats, and the authors were forced to the conclusion that this Cysticercoid must either be referred to *H. murina* or to some other as yet undescribed form, the scolex of which was indistinguishable from that of *H. murina*.

Hitherto the life-history of *H. murina* had been believed to be of a unique type. According to the researches of Grassi and Rovelli (*op. cit.* pp. 75-83) this tapeworm dispensed altogether with an intermediate host, and they had demonstrated that it passed its encysted stage in the walls of the intestine of the rat itself. This was supported on general grounds by the fact that this particular tapeworm usually occurred in enormous numbers, which would involve the ingestion of a correspondingly large number of intermediate hosts. The matter gained interest from the fact that *H. murina* was believed by some to be identical with *H. nana*, a dangerous tapeworm of man, although the identity was still a matter of dispute. In size and structure the two species were indistinguishable, and *H. nana* like *H. murina* occurred in enormous numbers. Further, no intermediate host had yet been discovered for *H. nana*. Now the discovery in the rat-flea of this Cysticercoid bearing such a close resemblance to the scolex of *H. murina* led to one of two conclusions: either that, as already mentioned, there might be some undescribed tapeworm of which the Cysticercoid was the larval stage, or that the rat-flea might function as an intermediate host of *H. murina*. The latter supposition, even if correct, did not necessarily disprove Grassi and Rovelli's results. Rats certainly ingested a large number of fleas from time to time, but it was difficult to imagine that they would acquire a very large infection with *H. murina* by this means; and if *H. nana* be identical with *H. murina* it was scarcely conceivable that a human being could accidentally swallow a sufficient number of fleas to give rise to an infection of over a thousand tapeworms, as was frequently found to be the case. It would still therefore be necessary to admit that the development of *H. murina* usually took place without an intermediate host, but that occasionally the rat-flea might function as such. With such a conclusion the life-history of *H. murina* became even more remarkable than before.

PAPERS.

1. On the Inheritance of the Webfoot Character in Pigeons.

By J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S.

[Received August 29, 1910: Read November 15, 1910.]

(Text-figures 3 & 4.)

In the P. Z. S. for 1905, p. 550, Mr. Staples Browne published a paper on the webbed-foot character in Pigeons, and from a series of careful experiments conducted by him the results seemed to show fairly conclusively that the webbed foot was a Mendelian character and was recessive to the normal or non-webbed foot.

In this paper the author drew an arbitrary line and counted as webbed all birds which showed on one foot a web at least to the first interphalangeal joint of the 2nd and 3rd digits and to the second interphalangeal joint of the 4th digit, any bird with less webbing being considered as normal. In my experiments I have followed his distinction for the sake of uniformity. All his results, with one exception, go to show that the webbed foot behaves as a pure Mendelian recessive character.

In the aberrant case two F_1 birds were mated together for two seasons, producing altogether 23 birds, in *none* of which the web appeared. Both these F_1 birds were subsequently tested and proved to be carrying the webbed character.

In the spring of 1905, Mr. Staples Browne kindly gave me a pair of his webbed birds [Exp. 14, *loc. cit.*], and during that year and the two subsequent years this pair produced nothing but webbed birds.

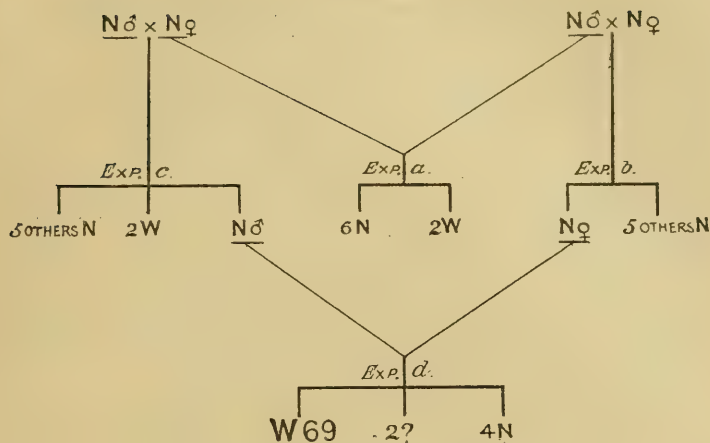
In 1907 Mr. F. W. Smalley, a well-known and successful breeder of fancy Pigeons, wrote to me in regard to some webbed birds which tended to make their appearance from time to time in his

TABLE I.

Exp. No.	♀.	Origin from	Also used in	♂.	Origin from	Also used in	Nature of Mating.	Feet.	
								Normal.	Webbed.
a ...	N (61)	...	c	N (126)	b	...	DR×DR	6	2
b ...	N (29)	...	...	N (126)	a	...	D × DR	6	0
c ...	N (61)	...	a	N (104)	...	...	DR×DR	6	2
d ...	N (10)	b	...	N (01)	c	...	DR×DR	6	1

stud. At my request he kindly sent me their pedigrees, from which it will be seen that the inheritance was strictly Mendelian and entirely bore out Mr. Staples Browne's results.

Text-fig. 3.



Pedigree of Mr. Smalley's bird (W 69).

(Birds underlined are supposed heterozygotes.)

A further and striking confirmation of this came to light this year (1910), when a web-footed bird suddenly appeared in whose direct ancestry on either side no webbed birds had been known for at least six generations; an investigation of the pedigree, however, showed one of the birds to have been a possible heterozygote, and on this assumption, and presuming all the subsequent matings to have been DR \times D, the case is quite simple. To some

TABLE II.

Exp. No.	♀.	Origin from	Also used in	♂.	Origin from	Also used in	Nature of Mating.	Feet.	
								Normal.	Webbed.
<i>e</i> ...	N (5)	<i>a</i>	...	N (50)	...	...	DR \times D	3	0
<i>f</i> ...	N (52)	<i>e</i>	...	N (30)	...	...	DR \times D	7	0
<i>g</i> ...	N (72)	<i>f</i>	...	N (11)	...	...	DR \times D	4	0
<i>h</i> ...	N (46)	...	...	N (54)	<i>g</i>	...	D \times DR	15	0
<i>i</i> ...	N (1376)	...	...	N (1354)	<i>h</i>	...	D \times DR	13	0
<i>k</i> ...	N (5486)	<i>i</i>	...	N (4863)	<i>h</i>	...	DR \times DR	2	1

it may appear strange that a DR bird should have been chosen in so many successive years, when the chances were even on the bird being a DR or pure Normal. It must, however, be remembered that since young were reared from a large proportion

of the birds noted in Table II., one would, in theory, have expected the web to have made its appearance in more than one instance, as the number of DR birds in Mr. Smalley's lofts must be considerable.

The fact remains that a webbed bird has been bred, and if its pedigree were not well-known one would have had to regard it as a "sport," without being able to account for its presence in any way.

So far, therefore, from well-attested evidence of independent breeders, the webbed character seems to be established beyond doubt as a Mendelian recessive.

In the summer of 1907, however, Mr. Smalley sent me a male web-footed bird (W 69), which I paired at once with one of the progeny (also webbed) of the pair of birds originally given me by Mr. Staples Browne. My object was merely to get a change of blood and to keep up a small stock of webbed birds.

Both the parents were webbed and, as we have seen, their ancestry showed that in both families the web had acted as a Mendelian recessive, so no doubt was felt but that the whole of the progeny would also be webbed. The result of this mating was five birds, *of which four were normal*.

For the past three years I have carefully mated these five birds and their descendants, with the results as shown in the following table:—

TABLE III.

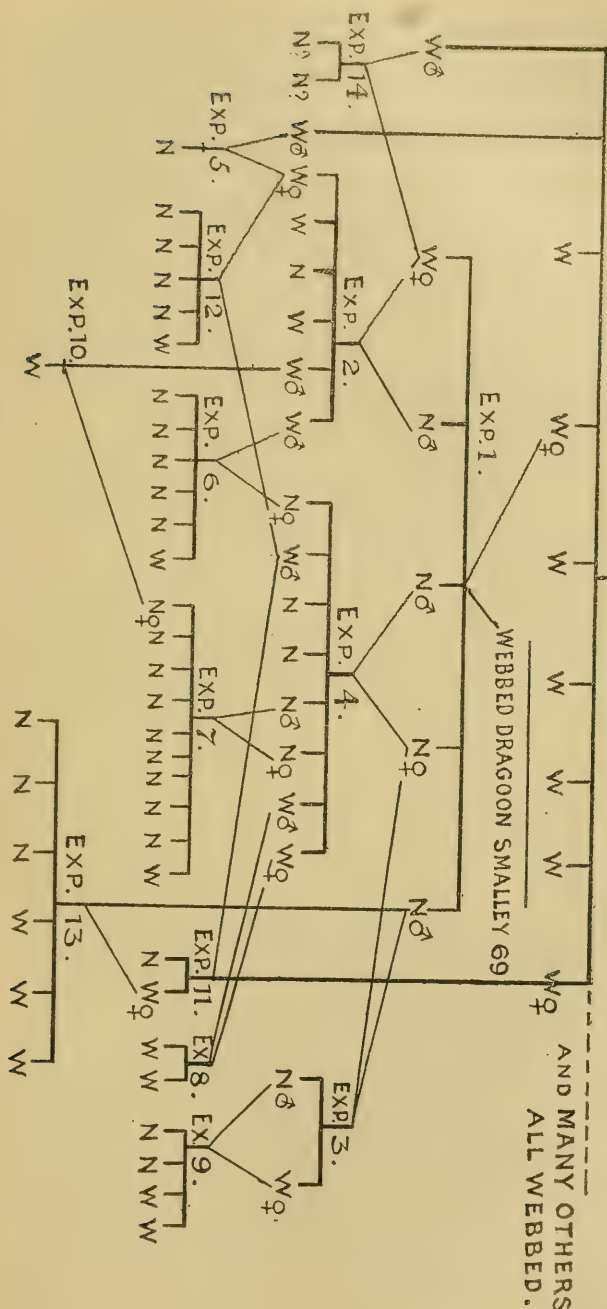
Exp. No.	♀.	Origin from	Also used in	♂.	Origin from	Also used in	Nature of Mating.	Feet.		
								Normal.	Webbed	
1 ...	W (7)	14 SB	...	W (69)	d	...	R×R	4	1	{ Mixed strains.
2 ...	W (a)	1	14	N (d)	1	...	...	1	5
3 ...	N (b)	1	4	N (13)	1	13	...	1	1	
4 ...	N (b)	1	3	N (c)	1	5	3	{ Mixed strains.
5 ...	W (24)	2	12	W (9)	14 SB	...	...	1	0
6 ...	N (29)	4	...	W (35)	2	...	In	5	1	
7 ...	N (22)	4	...	N (19)	4	...	theory all these matings must be	9	1	{ Mixed strains.
8 ...	W (23)	4	...	W (20)	4	...		0	2	
9 ...	W (27)	3	...	N (543)	3	...		2	2	
10 ...	N (533)	7	...	W (36)	2	0	1	{ Mixed strains.
11 ...	W (14)	14 SB	...	W (30)	4	12	R×R!	1	1	
12 ...	W (24)	2	5	W (30)	4	11	...	4	1	
13 ...	W (26)	11	...	N (13)	1	2	...	3	3	{ Mixed strains.
14 ...	W (a)	1	2	W (8)	14 SB	...	...	2*	0

* In both these birds the amount of webbing is just on the line fixed by Mr. Staples Browne.

If we look closely into the foregoing table, we may note that whenever the apparent Normals are mated together we get some webs. This has been done in experiments 3, 4, and 7, the total result being 12 normals to 6 webs. Were these normals heterozygotes we should have expected 12 Normals and 4 Webs.

WEBBED PAIRS FROM STAPLES BROWN. EX.14. P.Z.S.1905.

Text-fig. 4.



Genealogical Table showing matings and results in mixed strains.

If we take the Normal-Web matings, as in experiments 2, 6, 9, 10, and 13, we find the total results to be 11 Normals to 10 Webs. In this case were the Normals heterozygotes we should expect equality, which is practically the result attained.

Lastly, when we mate Webs to Webs, as has been done in Exps. 1, 5, 8, 11, 12, and 14, we should expect Webs only, and this result was only attained in one case (Exp. 8), where only two birds both webbed were reared. In the other five cases together 15 birds were reared, 12 Normal and 3 Webbed. The proportions are almost exact for a $DR \times DR$ mating, which, of course, we know they cannot be; but it is not without significance to note that in four out of these five experiments the matings were a cross between the mixed strain and Mr. Staples Browne's strain.

These, then, are the facts, and at present it seems difficult to reconcile them with the Mendelian theory, although they certainly seem to show that the inheritance of this character is to a certain extent in accordance with that theory.

According to previous and contemporary work on this character, no individual should have had a normal foot. If, however, the Normals that have appeared be considered as heterozygotes, then, considering the small numbers, the results from the matings are not greatly at variance with what we should expect.

As regards the Webs (in these experiments), when mated with Normals they behave as recessives, but when mated with other Webs of either the mixed or of Staples Browne's strain they produce Normals to Webs in a ratio closely approximating 3:1. Such a result in the case of no less than five matings seems to show pretty conclusively that the joining of the two strains has produced a factor disturbing the normal course of the Mendelian inheritance.

It must be carefully noted that each strain by itself breeds true according to Mendel's laws and that the disturbing factor is not brought in from one side only, but is due to the intermixture of the two strains.

Mention should perhaps be made of a suggestion by Prof. Bateson, to whom I wrote on the subject. This was that the webbed foot was possibly a double character and that the web between digits 2 and 3 had a separate inheritance from that between digits 3 and 4. Now, if we look at Exp. 1 in this light, we find that in $\frac{2}{3}$ the male is very slightly webbed (practically normal) and that in $\frac{1}{4}$ he is fully webbed. In the female, on the other hand, the webbing in $\frac{2}{3}$ is very full and in $\frac{1}{4}$ extremely small.

We could thus suppose the male in Exp. 1 to be $\frac{2}{3}$ N (W) $\frac{1}{4}$ WW, female $\frac{2}{3}$ WW $\frac{1}{4}$ N(W); this would then give in F₁ $\frac{3}{4}$ Normals and Webs equally, $\frac{1}{4}$ Normals and Webs equally, so that we might expect pure Normals ($\frac{2}{3}$ N $\frac{1}{4}$ W, $\frac{2}{3}$ W $\frac{1}{4}$ N) and pure Webs in equal numbers—as a matter of fact, 4 were Normals and 1 $\frac{2}{3}$ N $\frac{1}{4}$ W.

This suggestion, however, becomes untenable for other reasons. If we examine the birds I bred for Mr. Staples Browne (Exp. 14,

loc. cit.), together with 5 more individuals reared since, we find that the old male no. 19 SB was undoubtedly $\frac{2}{3}$ WW $\frac{3}{4}$ N (W) and the female was the same; consequently all birds bred from this pair should be webbed in $\frac{2}{3}$ and a quarter of them webbed in $\frac{3}{4}$. As a matter of fact, out of 10 birds, 1 is normal in $\frac{2}{3}$, 3 are webbed in $\frac{3}{4}$, and one has all four toes fully webbed.

It is unnecessary, therefore, to follow up the matter further, as slight deviations appear in almost every mating.

We must, therefore, be driven back to the suggestion that a factor composed of two parts (cryptomeres), one of which is contained in each strain, causes the web to be suppressed or concealed.

On this assumption none of the results attained are at variance with the Mendelian theory. The proportions, however, do not fit in, but as the numbers are small this does not count for much. On the average the extent of the webbing shows a tendency to diminish and the foot to approximate to the normal as compared with birds of either of the pure strains, and in only one bird, bred in Exp. 9, has the web included the hallux.

Owing to lack of space and pressure of other experiments, I do not propose to pursue this inquiry further, but should anyone wish to follow it up I shall be very pleased to place all my material at his disposal.

My best thanks are due to Mr. Smalley, who has not only supplied me with full and accurate particulars from his pedigree book, but has also during the past year kept and bred many of the birds in his lofts.

2. Notes on the little-known Lizard *Lacerta jacksoni* Blgr., with Special Reference to its Cranial Characters. By EDWARD DEGEN, F.Z.S.

[Received September 15, 1910: Read November 15, 1910.]

(Text-figures 5-7.)

Through the kindness of Mr. G. A. Boulenger, F.R.S., V.P.Z.S., a series of seven specimens of *Lacerta jacksoni* has been placed in my hands for investigation. These specimens, recently procured by Mr. R. Kemp at Mumias, Mount Elgon District, British East Africa, at an altitude of 7000 feet, reached the British Museum in a bad state of preservation; opportunity was therefore taken to submit the cranial structure of this little-known species to a careful examination, the results of which are now placed on record.

Of the seven specimens six were males and one female.

The specimens from which the skulls were prepared were a small, but quite adult male, measuring 70 mm. from snout to vent, and the single female, measuring 68 mm. The dimensions

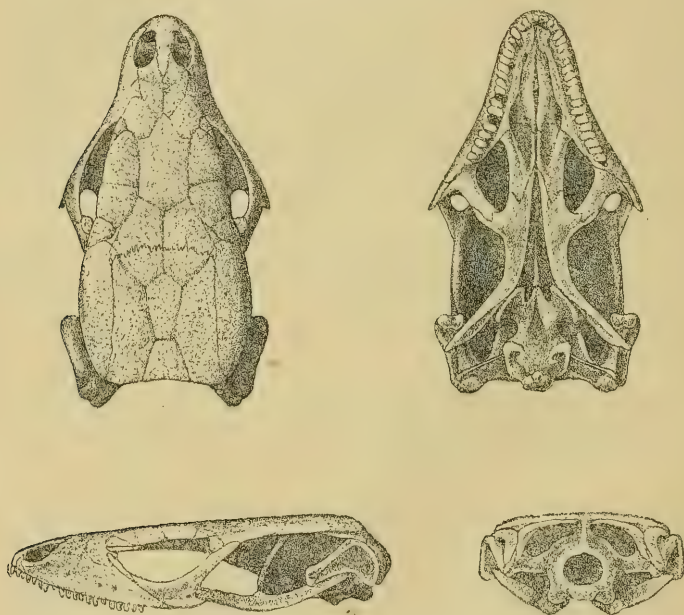
of the former therefore are about the same as those of the single male specimen from which the species was originally described and figured*, after its discovery at "Ravine Station," Mau Mountains, British East Africa, at an altitude similar to that at which the specimens now studied were obtained.

DESCRIPTION OF THE SKULL OF THE MALE.

DIMENSIONS.—Total length 21 mm.; width 12 mm. (as measured between the extreme points of the zygomatic processes of the jugular bones); height 6 mm.

Its width is therefore contained 1·9 times in its length, and its height 3·3 times.

Text-fig. 5.



Skull of male.

Upper, lower, lateral and posterior aspects. $\times 2\frac{1}{2}$.

GENERAL CONFIGURATION.—Remarkably depressed, as may be noted from its proportionate dimensions, and further seen in the above figure representing the profile.

Facial portion. Snout short, broadish at base, terminating in a bluntly rounded-off præmaxillary.

* "On New Lizards from the Interior of British East Africa," by G. A. Boulenger, F.R.S., Proc. Zool. Soc. 1899, pp. 96 & 97, pl. x.

CRANIUM (*Fronto-parietal portion*).—Squarish. The whole of the upper surface from the anterior borders of the nasals to the posterior margin of the parietal quite flat, and forming an almost perfectly level plane.

Dermal incrustation. Evenly spread, profuse, but highly porous, and covering the whole of the upper surface, including a small portion of the nasal process of the præmaxillary bone.

Lamina supraciliaris (text-fig. 6, A, p. 23) (Supra-orbital region). Completely ossified; 4 supraoculars, and 1 supraciliary on each side.

Supraorbital bones (text-fig. 6, B). Small; irregularly triangular and thickish, convex laterally. The internal angles terminating in a hook-like spine and the posterior margins irregularly serrated. Their lateral edges barely showing on the exterior and almost wholly concealed under the first supraciliary scutes.

Pterygoid bones. Toothless; moderately diverging immediately in front of the dilated lateral processes of the basisphenoid.

Postfrontals forming a single plate.

A *Retrociliary* present (text-fig. 6, A).

Dermal ossification of Temporal region. Supratemporalia 1 and 2 partially ossified.

Dentition. Number of teeth in præmaxillary 9; in each maxillary 18.

Nasal apertures (text-fig. 6, D). Subcircular, the longitudinal diameter the greater.

Parietal Region.—This, as in all Lacertidæ, is clearly defined in contour, and forms the greatest expanse of the cranial roof.

Its anterior borders practically are coincident with the fronto-parietal suture and the postorbital margins of the adjacent postfrontals. Posteriorly, the parietal is produced well backwards, and ends in a straight edge, the latter being the result of an increased deposit of the crusta calcarea—a feature mostly absent in the very young, in which this portion is concavely crescentic. This edge connects the two outward and backwardly directed processus parietales, spanning over the parotic processes, the processus ascendens of the supraoccipital bone, and covering the greater part of the latter in this species, so that the pars condyloidea of the occipital alone projects beyond it when the skull is viewed from above.

The parietal processes, slightly triangular in a transverse section at their terminal parts, are quite flat at their basal portions and are mere continuations of the median portions of the parietal itself. They have not, as is the case with the majority of the Wall-Lizards in which the facies cranialis is more elevated, the downwardly directed ridges set at right angles with their bases, in order to establish the contact with the underlying supraoccipital.

No *Foramen parietale*. (For special remarks on this striking feature refer to p. 29 at the end of the description of cranial characters.)

The *Postfrontals*, which are joined laterally to the single parietal bone by means of ordinary sutures, and which extend the whole length of the parietal as far backwards as the supratemporal bones, complete the cranial roof. They form a single plate in the present species, with every trace of their former sutures completely obliterated through fusion of the two component parts of which they consist in a great number of Lizards. This is a condition found to exist also in *Lacerta simonyi*, *L. atlantica*, *L. ocellata*, *L. viridis*, *L. galloti*, *L. dugesii*, and *L. levis* (in the latter species the squamosal also fuses with the postfrontal plate). In *Lacerta jacksoni* these bones are on the same horizontal plane with the parietal to their outermost margins, which in so many of the Lizards of the "*muralis*" group are strongly convex and appreciably bent downward towards the temporal foramen.

A similar feature, which imparts such a quadrangular aspect to this portion of the skull, is observable in the case of *Lacerta simonyi**, *L. atlantica*, *L. ocellata*, *L. viridis*, *L. galloti*, *L. dugesii*, *L. levis*, *Algiroides nigropunctatus*; and among *L. muralis* forms in the varieties *nigriventris* and *serpa*.

Frontal.—Originally paired (in very young specimens) it is single in the skull before me as well as in the majority of the members of this genus when adult. Its interorbital width, at the narrowest part of its anterior portion, measures exactly one-half of its posterior and widest portion, which is to be found in a line drawn between supraocularia 4, the latter coinciding approximately with the fronto-parietal suture. In proportion, therefore, this interorbital width is greater than in most of the *muralis*-like forms, except for the skull of a male specimen of the typical form from Vienna, which is also greatly depressed. In the length of the skull this dimension is contained six times; whereas in the majority of skulls belonging to the *muralis* group it varies between seven and eight times. It further equals the width of supraocularia 2 and 3; also that of the space between the inner dentary ridges (*laminæ horizontales*) of the maxillary bones (measured across the *apertura narium interna*), and is of the same length exactly as the *columella cranii* (epipterygoid, Parker). Equally distinguished in respect to this broad interorbital diameter are—apart, again, from all the previously enumerated Atlantic Island forms and others named—the skulls of *L. agilis* and *levis*, and of the more typical *muralis* forms those of *L. chlorogaster*, *L. saxicola*, and *L. derjugini*†. Further, in *Algiroides nigropunctatus* this region is also of a broader type; but according to Siebenrock‡ it differs in the persistence of the

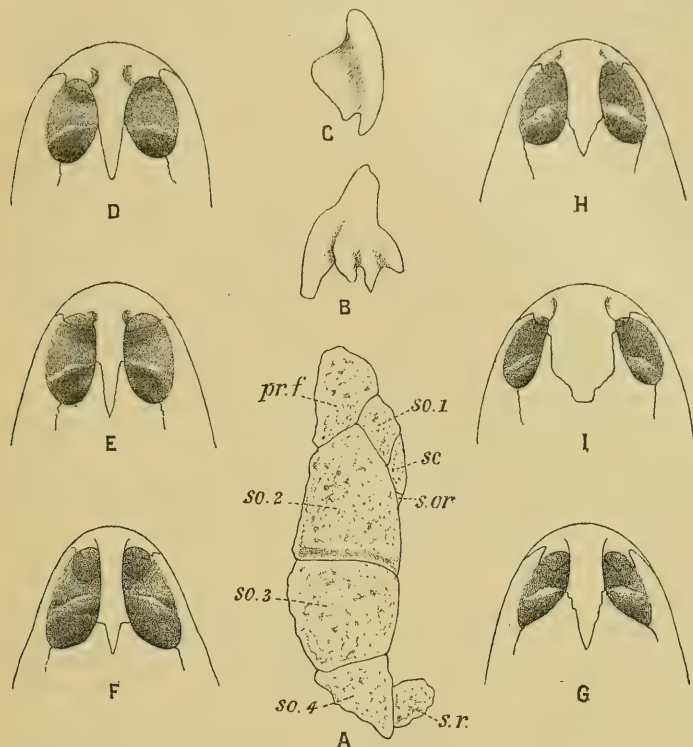
* Cf. "Das Skelet der *Lacerta simonyi* Steind. und der Lacertenfamilie überhaupt," von Friedrich Siebenrock, Sitzungs. Kais. Akad. der Wissenschaften in Wien, vol. ciii. part i., April 1894, Taf. ii. figs. 8 & 11.

† Cfr. L. von Méhely, "Materialien zu einer Systematik und Phylogenie der Muralis-ähnlichen Lacerten," Ann. Mus. Nat. Hungarici, Band vii. 1909, tab. xix. fig. 9 & tab. xxii. figs. 3 & 5.

‡ L. c. p. 23.

two original parts composing the single frontal in the adult of this genus also*.

Text-fig. 6.



A. Lamina supraciliaris of *Lacerta jacksoni*, ♂. Right side.

B. Supraorbital bone of *L. jacksoni*, ♂. Right side, ventral aspect.

C. Supraorbital bone of *L. jacksoni*, ♀. Left side, ventral aspect.

D-I. Showing configuration of nasal process of premaxillary and outer nasal apertures of—(D) *L. jacksoni*, ♂; (E) *L. jacksoni*, ♀; (F) *L. muralis*, f. *typica*, ♂, from Vienna; (G) *L. muralis*, f. *typica*, ♂, from Turin; (H) *L. vivipara*, ♂; (I) *L. agilis*, ♂. $\times 6\frac{1}{2}$.

pr.f., præfrontale; *so.*, scuta supraocularia (1-4); *sc.*, scutum supraciliare;
s.r., scutum retrociliare; *s.or.*, supraorbital.

Premaxillary.—Its backwardly directed nasal process (text-fig. 6, D) is rather short and exceptionally broad at its base, where it is widely expanded on both sides, close behind the

* The skull of the male specimen of this species in the British Museum Collections does not bear out this statement, the said suture being wholly obliterated by incrustation.

laterally situated nerve-canals which at this point perforate the bone. Other examples of a very broad nasal process of the premaxillary are to be found in *Lacerta ocellata*, *L. viridis*, *L. agilis* (text-fig. 6, I); and reference to Dr. Siebenrock's text and figures for *L. simonyi** also shows the latter to belong distinctly to the broad type, and consequently not—as he points out, when referring to this feature—being distinguished by a “long and slender” type of processus nasalis the same as in *Eremias arguta*, with which he likens *L. simonyi* as regards this character.

In *Lacerta dugesii* I find the shape of the nasal process occupies a position intermediate between *L. jacksoni*, the species here dealt with, and those possessing a nasal process of distinctly slender and elongate shape. Most of the true *muralis* forms belong to the latter (text-fig. 6, F & G). *Lacerta echinata*, *L. vivipara* (text-fig. 6, H), and *L. lævis* must also be considered intermediate forms in this respect. Allowance for individual variation, however, must be made, as the examination of three skulls of the latter species, all males, clearly demonstrates.

The very low angle at which this nasal process rises at its issue from the maxillary portion of the bone is merely due to the strongly depressed type of the skull itself, as, in fact, in any of the typically platycephalous forms, e. g. *L. mosorensis* or *L. oxycephala*, and differing from the more or less convex types of skulls in which this process is more highly arched.

Nasal bones.—Owing to the profuse incrustation of the upper surface of the skull, their contours in this specimen are very ill-defined. All that can be said on this head is that they are oblong, of a scaly nature, and that they widely diverge behind to receive between them the anterior and pointed processus nasalis of the frontal bone. Their length approximately equals their combined width at the widest part between the præfrontal bones.

The *Præfrontals* also appear very irregular in their upper outlines and in their relations to the maxillaries, the frontal, and the nasals. The spinous posterior process, which forms the anterior border of the margo supraorbitalis, seemingly does not reach much farther backward here than the suture between the first and the second supraorbitals.

The *Lacrymal* bones are clearly defined, exceedingly thin, narrow, and blade-like in shape. In their situation at the anterior angle of the orbital cavity, they form, together with the incisura lacrymalis of the præfrontals, a well-developed *foramen lacrymale*.

Jugulars.—Their zygomatic processes are represented by a rather short, but acutely pointed spine. Their temporal processes are somewhat straighter than is the case in *Lizards* having deeper skulls, in all of which they usually are of a more sigmoid form.

* *L. c.* p. 32, Taf. ii. fig. 8.

OCCIPITAL SEGMENT.—*Supraoccipital*. Its epiotic portion is nearly horizontal and only slightly inclines towards the posterior free edge, which forms the upper margin of the foramen magnum. The processus ascendens (processus spinosus, Clason) rises rather abruptly and almost vertically from the anterior portion of the supraoccipital, and constitutes the exclusive support of the parietal roof.

The processus ascendens is not flanked on either side by any apophysial eminence of the supraoccipital, which so frequently acquires the same height as does the spinous process itself, in order to increase the connecting-area with the parietal, such as is the case in *Lacerta oxycephala*, *L. saxicola*, *L. defilippi**, *L. chlorogaster* (boettgeri Méh.), and *L. mosorensis*, among some of the flat-headed species; or as in *Lacerta muralis* forma *typica*, the varieties *tiligueria*, *campestris*, *nigriventris*, &c., as well as *Lacerta vivipara*, among the more highly and convexly-roofed forms where it also occurs.

A similar pillar arrangement as pointed out for *Lacerta jacksoni* is present also in *L. simonyi*, where it is carried out to even greater perfection owing to the increased elevation of the parietal roof†; in *L. galloti*, *L. viridis*, *L. dugesii*, and *L. echinata*, proportionate, of course, to their respective dimensions of height. This arrangement is of rare occurrence in a strongly depressed, practically platycephalous Lizard, and equally so in the case of the more pronounced pyramidocephalous forms, amongst which I find it occurs (in two specimens) in the varieties *serpa* and *lilfordi* only.

The *Basioccipital*‡ and *Basisphenoid*§ in no essential deviate in their configuration from the outlines usual in the genus for this region.

The *Parasphenoid* is feebly ossified at its base, whereas its centre remains cartilaginous.

The *Orbitosphenoid* bones have a broadish appearance on account of their reduced size, the latter being due to the depressed membranous portion of the cranium.

The *Squamosals*, usually slender and delicately shaped, which in so many of the smaller forms of *Lacerta* are only loosely connected by ligamentous tissue with the outer postfrontals, are here strongly developed and anteriorly quite fused to the latter. Their posterior ends, which articulate with the quadrates, are broadly expanded and, together with the parietal processes and the much reduced supratemporals which wedge themselves

* Cfr. Méhely, "Materialien etc.," Ann. Mus. Nat. Hung., Bd. vii. 1909, tab. xvi. fig. 6, tab. xix. figs. 3 & 10, tab. xxii. fig. 6.

† Cfr. Siebenrock, l. c. Taf. ii. fig. 9.

‡ Posteriorly and slightly in front of the foramen magnum there is a small tubercular process in the male specimen, which is absent in the female.

§ The foramen by which a branch of the jugular vein leaves the skull, and which Siebenrock (l. c. p. 11) regards as the result of synostosis of a special process with the anterior angle above it in the case of the Canary Island Lizards, but as absent in the European forms as well as in *L. dugesii*, is represented in *L. jacksoni* by ligament only.

between these two latero-posterior angles of the skull, unite with the processus parotici in such a way that the foramen supratemporale, conspicuous for its relative large size even in the adults of the pyramidocephalous forms like *Lacerta muralis* varieties *flumana*, *serpa*, *campestris*, *pityusensis*, and others, is here nearly closed up as much, for instance, as in *L. laevis*.

The *Presphenoid*, which in some *Lacertæ* is a slender ossification of the ethmoidal region in the membranous *septum orbitale*, is here reduced to a small cartilaginous band in which calcifications in the shape of granules are imbedded.

The *Columella cranii*, for a skull of the inferior dimensions of the present one, are exceptionally thick and strongly bent laterally—particularly so at their parietal ends, where they are in close contact with the *ala sphenoidæ*. Thus they differ somewhat from the more delicate, either linear or slightly sigmoid thin structures frequently met with in the majority of other Wall-Lizards; but this condition is the rule in the very young, as already pointed out by Siebenrock*.

The *Quadrata* and *Ossa transversa* both answer to the general form of description for all these Lizards.

The *Vomer plates* are closely approximated to each other medially along their entire length, but intimately united only at their anterior ends. The lacuna pterygo-vomerina does not extend beyond the most posterior portion of the palate-bones, which latter also unite with each other along their greater length, producing the *crista vomerina* which is continued on to the palatines.

MANDIBLE.—This consists of five elements only, a condition stated by Leydig to be typical of the *Lacertæ*, and further confirmed also by Siebenrock† in the fully adult *Lacerta atlantica*, *L. muralis* var. *melissellensis*, *L. cærulea*, *L. oxycephala*, and *L. mosorensis*, a condition brought about by the fusion of the supra-angulare with the articulare; whereas in *L. simonyi*, *ocellata*, *galloti*, and *viridis*‡, according to Siebenrock, these two bones remain separated throughout life.

The number of teeth in each ramus is 23.

DESCRIPTION OF THE SKULL OF THE FEMALE.

DIMENSIONS.—Length 15 mm.; width 9 mm.; height 4 mm.

Its width is therefore contained 1·6 times in its length, and its height 3·3 times.

GENERAL CONFIGURATION.—Strongly depressed in the same proportions as in the male.

In texture the bones are rather delicate, such as is characteristically the case in all platycephalous species of Lizards so

* *L. c. p.* 52.

† *L. c. p.* 53.

‡ In the skull of a specimen of this species from Bozen, Tyrol, these two bones, though fused slightly, show their original longitudinal sutures in their anterior portions.

typically represented by *Lacerta mosorensis*, *oxycephala*, &c. Except for the bones composing the occipital segment, and the usually more massive præmaxillary and maxillaries, all the others assume a more or less foliated form.

Facial portion. The snout appears much shorter and broader than in the larger male, but is slightly more pointed in front.

Text-fig. 7.



Skull of female.

Upper, lower, lateral and posterior aspects. $\times 3\frac{1}{2}$.

CRANIUM (*Fronto-parietal region*).—Slightly broader than long in proportion, owing to the incomplete development of its posterior margin, which is crescentic in shape as in all young examples. Its median edge therefore barely reaches the anterior margin of the supraoccipital. The upper surface, quite horizontal in its main configuration, is longitudinally slightly undulated by alternately being concave in its fronto-nasal and fronto-parietal parts respectively, and convex in the intervening frontal and parietal areas.

Dermal incrustation. Very sparse and transparent. The sulci of the blood-vessels are sharply defined for their former ramifications.

Lamina supraciliaris. Completely ossified also, as in the male, and not bearing a trace of a membranous fontanelle.

Supraorbitals (text-fig. 6, C, p. 23). More regularly triangular than in the male, also slightly more massive. Their thickened and strongly convex lateral margins, scarcely exposed in the male, are here so to a greater extent on both sides (ascertained before accidental displacement of their dermal plates on one side in the later manipulation of the skull), having been covered partially only by the supraciliary.

Pterygoids. Diverging slightly more than in the male specimen. Teeth absent.

Postfrontals. Forming single plates also. Faint traces of an earlier existing suture, as recorded to exist in the very young stages of *Lacerta dugesii*, *ocellata*, and *muralis* by Siebenrock*, are discernible anteriorly only. In their posterior portions (postorbital margins) their fusion is complete.

A minutely developed *Retrociliary* present.

Dermal ossifications of Temporal region. I have been unable to find any.

Dentition. Number of teeth in præmaxillary 9, in each maxillary 15-16.

Nasal apertures (text-fig. 6, E). These are slightly narrower than in the male, and therefore longer in proportion.

Parietal Region.—Except for its morphogenetically inferior development of the posterior margin, which is a common feature of all the young, this does not deviate in any essential from the usual conditions. Its relation to the supraoccipital alone requires some explanation (see p. 29), which latter bone is, owing to the development stage, wholly exposed and not yet bridged over as it is in the male.

The *Foramen parietale* is absent, as in the male.

Frontal.—The median suture is discernible in its greater length, which is quite in accordance with the remarks already made on this subject. The width of the frontal at its narrowest point (between the *margines orbitales*) is equal to that of supraocular 3. The frontal is actually and relatively narrower than that of the male, its width being slightly less than half the length, and a seventh of the total length of the skull, whilst in the male the similar measurement shows that the frontal is relatively larger. The width of the female frontal is three-fourths of the length of the *columella cranii*, and in this measurement, as well as when it is compared with the width between the internal *laminæ horizontales* (taken diagonally across the *choanæ*), the relative and actual inferiority of size as compared with the male is shown.

Præmaxillary (text-fig. 6, E).—The nasal process of this bone is on the whole longer and narrower than in the male. It also terminates posteriorly in a much more finely drawn-out point. It is quite devoid of any calcareous incrustation. Anteriorly it rises from the maxillary portion of the bone at a similar acute

* *L. c.* p. 75.

angle to its horizontal plane as in the male, but is less expanded at its base, immediately behind the constriction between the nerve-holes.

The *Nasal bones*, which, owing to extensive incrustation, in the male specimen were described as ill-defined, are here quite distinct in their entirety. Anteriorly their proximal processes, between which the nasal process of the præmaxillary is wedged, extend to the middle of the latter. Their lateral margins, shorter than those forming the median suture and moreover less decidedly linear, are parallel to each other. Their posterior edges, scale-like in shape, and imbricating in a similar manner on the frontals, are characteristic in having from 2 to 3 pointed lobes, of which the median ones are the longest, so as to become a fork into the prongs of which the median process of the frontal penetrates.

The *Præfrontals* also are more clearly defined in the female. They show their posterior frontal processes, which constitute the margo orbitalis anteriorly, to be spurs which extend nearly as far back as the suture between supraocularies 2 and 3.

The *Jugulars* do not differ from those of the male.

OCCIPITAL SEGMENT.—The *Supraoccipital* is united along its entire upper margin with the posterior edge of the parietal bone. The processus ascendens, so tolerably well developed and forming the sole support of the parietal in the male, is quite rudimentary here and reduced to a tubercle only. It is lower even than are the apophysial elevations of the epiotic portions of the bone, and, together with the epiphysial cartilaginous spine and a small portion of the membranous cranium, is laid bare and quite unprotected by the parietal. The sutures between the supraoccipital and the pleurooccipitals are perfectly distinct. The foramina retrofrontalia, in consequence of this extended transverse connection between the parietal and the supraoccipital, are more markedly reduced than in the male.

The *Basioccipital* and *Basisphenoid* are not fused as in the male, the suture between them showing distinctly (text-fig. 7, p. 27).

The *Squamosals* are flatter and less curved downwards than in the male.

The *Vomer plates* are more loosely united than in the male; but the *Palatines*, though more distinctly united, have their sagittal ridges imperfectly developed as compared with those of the male. The *sulci palatinae* are also shallower in this skull.

MANDIBLE.—This consists of the six elements, of which each ramus is composed in all immature Lizards as pointed out by Siebenrock, the supra-angulare and articulare being not yet united by fusion.

On the Absence of the Foramen parietale.

After first ascribing the absence of the orifice for the pineal eye in the skull of the male to purely pathogenic causes, or to

a possibly individual aberration, both of these assumptions were dispelled on the discovery of this peculiarity in the female also.

An examination of the remaining five specimens preserved in alcohol, as well as of the type specimen referred to (*antea*, p. 20), and of a second female more recently described* (all in the Collection of the British Museum), readily confirmed its specific importance, since not one of them bore the least trace of the presence of this morphological feature.

Besides the simultaneous observation of its absence in *Zonosaurus madagascariensis*, belonging to the neighbouring family Gerrhosauridæ, a more methodical search among the rich material of the British Museum Collections revealed the following genera and species belonging to the family of Lacertidæ as being devoid also of the foramen parietale:—

<i>Poromera fordii</i> .	Benito River, Spanish Guinea.
<i>Lacerta echinata</i> .	Kribi River, Cameroon.
<i>Algiroides africanus</i> .	Uganda.
<i>Nucras delalandii</i> .	Natal.
<i>Latastia hardeggeri</i> .	Somaliland.
" <i>neumanni</i> .	Arabia.
" <i>degeni</i> .	Somaliland.
" <i>spinalis</i> .	"
" <i>phillipsii</i> .	"
<i>Gastropholis vittata</i> .	Zanzibar.
<i>Holaspis guentheri</i> .	Benito R., Spanish Guinea.

As the above list shows, cases of absence of the parietal foramen occur in several monotypic genera, also in the specifically numerous genus *Latastia* in no less than five species out of ten. Yet it is rather remarkable to find such a character restricted to two species only in a large genus such as *Lacerta*.

But more remarkable, perhaps, is the fact that all the forms thus deprived of the foramen belong to the African Continent, and that in the not strictly African genera it is restricted to African representatives.

Some of the remaining genera of this family, even of purely African habitat, do not contribute any specific forms which exhibit this negative character. It is curious to note, moreover, that among the upwards of thirty known species of the genus *Eremias*, about twenty of which are found in Africa, no exception to the presence of the parietal foramen could be found.

The sum total of cranial characters, as shown principally in the immature skull of the female, points to *Lacerta jacksoni* being

* G. A. Boulenger, "Ruwenzori Expedition Reports," Trans. Zool. Soc. vol. xix. part iii., Dec. 1909, p. 242.

closely allied to *L. muralis*, forma *typica*. It agrees with the latter as well as with *L. mosorensis* in the strongly depressed and more broadly expanded skull-structure in general. Also in the wider interorbital region, likewise a marked feature in *Lacerta vivipara*. Also in the mode in which the connection between the posterior portion of the parietal and that of the supraoccipital presents itself; in the absence of teeth on the pterygoid bones, and in the degree of divergence of these latter, as well as in the configuration of the basioccipital and the basisphenoid. Further, in the shortened muzzle with broadened base, and in the anteriorly broadened nasal process of the premaxillary bone (text-fig. 6, D), well indicated in the typical form of *L. muralis* from Turin (text-fig. 6, G), but assuming its widest proportions in *Lacerta agilis* (text-fig. 6, I).

The total absence of supraocular fontanelles, notwithstanding the typically platycephalous structure, together with the ontogenetically early complete fusion to one composite plate of the postfrontals, would justify our referring this type of skull to the group of Lizards to which the term of *Neolacertæ** has recently been given.

However, considering the views held and recently enunciated by writers on the subject of the phylogenetic relation of some of these characters, it is rather surprising to find undivided postfrontals also in species belonging to entirely different genera, such as *Eremias*, as Prof. v. Méhely† regards that genus as one of the prototypes of archæolacertic forms of this family because of the characters of its *lepidosis*.

I might add that in *Acanthodactylus boskianus*‡, a lizard to which Siebenrock§ ascribes a divided condition of the postfrontals, I find them to be completely fused into one plate in the skull of a female in the British Museum Collections.

A perfectly obliterated suture between the two postfrontals I also find in a female specimen of *Scapteira knoxii*, another decidedly platycephalous species.

Thus, beyond some more or less doubtful points in regard to a satisfactory solution concerning the question of phylogeny, skulls of females do not seem to afford trustworthy indications from which to draw conclusions as to affinities. It is to that of the male, so far as an examination of the present limited material is concerned, that one must turn for better results.

As pointed out in the detailed part of the description, the tabular surface (inclusive of the postfrontals) is a very conspicuous feature of this male skull when taken in conjunction with the quadrangular and posteriorly well projecting parietal region. A near approach in this respect is to be found in a male specimen of *Lacerta muralis* of the variety *lilfordi*, a form restricted to

* L. v. Méhely, *Materialien*, l. c.

† *Ib.*

‡ Sex not stated by Siebenrock.

§ Cf. "Das Skelet der *Lacerta simonyi*," Sitzb. Akad. Wiss. Wien, 1894, p. 37.

the Balearic Islands. Though unquestionably more pyramidocephalous in regard to its superstructure, it nevertheless holds a position somewhat intermediate between *L. jacksoni* and some of the more pronounced pyramidocephalous forms in this group in regard to this particular feature.

The variety *lilfordi* also shows the same exclusive pillar arrangement of the processus ascendens for sole support of the parietal roof, which is so prominent a feature also in all the larger forms of Lizards from the Atlantic Islands such as *L. simonyi*, *galloti*, *atlantica*, and also *L. dugesii** (except in regard to a modification in the basal portions of the parietal process), all differing by having pterygoid teeth, and all of which, except the latter, have strongly ossified temporal regions. These dermal ossifications in *Lacerta jacksoni*, as may have been seen, are present in a rudimentary state in two of the supratemporal scutes. Specimens of *Lacerta viridis*, *agilis*, and *laevis* may be quoted as further examples of characteristic forms in which the postfrontals are single plates, with perfectly analogous conditions in the relations between parietal and supraoccipital.

Also *Lacerta echinata*, from West Africa (except for its more elongate skull), in which the processus ascendens, typically pyramidal, does not enter into direct contact with the parietal, but is actually separated from it by confluence of the foramina retrofrontalia.

But it is the shape of the nasal process of the præmaxillary perhaps, as previously remarked on in the male, which may also provide a likely indication of closer affinity with some of the Lizards of the Canary Islands and the European species of *Lacerta*, viz. *ocellata*, *viridis*, and *agilis*—a character in which the Balearic variety *lilfordi* does not share, being distinguished by a narrower and very slender nasal process.

So far as the topography of the skull reveals phylogenetic affinity, it would appear that *Lacerta jacksoni* came from a Palearctic stock, but also exhibits special relationships between the West African and Atlantic Island forms.

Remarks on Characters of Lepidosis in Lacerta jacksoni.

Dimensions.—In regard to size, five specimens, all of them males, are larger than the type of the species; the two biggest measuring 86 mm. from snout to vent, and consequently of about the same length as is the largest of the males of Dr. Peracca's series (consisting of seven specimens also), the length of which is given as 85.5 mm.

The male specimen, from which the skull was prepared for the

* Siebenrock (*vide l. c.* p. 36) includes this species amongst those having divided postfrontals. The specimens at my disposal, from the British Museum Collections, show them distinctly to be single plates, with no indication of former sutures.

foregoing description, measured 70 mm.; equal to the length of the type specimen. It is therefore only slightly longer than the skull of the female which was sacrificed for the same purpose, the length of the latter from snout to vent being 67 mm. Though differing by 3 mm. only, the sexual discrepancy in the size of the heads is a striking one: 19 mm. for the male against 14 mm. for the female.

Analogous specimens for size in Dr. Peracca's series show corresponding differences, viz. 20 mm. for the head of a male and 15.5 mm. for a female.

Ventral Plates.—The number of the ventral plate series varies in the Mount Elgon specimens, three of these having 6 longitudinal rows only and four of them having 8, which is the same as in the type of the species.

For the Turin Museum specimens their number is uniformly stated to be 6; but to judge from a footnote in connection with this point, the author was fully cognisant of the presence of supplementary series* for some of his specimens, but hesitated to accord them serial rank on account of the inferior size of the scutes which form the outermost rows.

In several of the Mount Elgon specimens these latter are sufficiently well developed to be considered as a series of ventrals.

Transversely, the minimum of the plates in the Elgon specimens is 23 in an adult male, and the maximum 26 respectively for the male and the female from which the skulls have been prepared.

For the Turin Museum series this minimum of 23 occurs in two males, one quite young and the other larger, whereas for the largest and fully adult the number is 24, but the highest figures of 27 and 28 are reached by two females of the same lot; the first number being identical with that of the Ruwenzori female in the British Museum Collections, whereas the female specimen from Mount Elgon has only 24 rows of these scutes.

It must be borne in mind that female lizards, having the body more elongate in proportion than the males, usually possess a higher number of transverse series of ventral plates.

Scales across the middle of the Body.—These range between 38 and 43, giving an average of about 40, the same as recorded for the type specimen, provided we except the male from which the skull was prepared and which showed the abnormally high number of 49. The Ruwenzori female has 37, a number close to the average of 36 as represented in the Turin Museum series, where they vary between 34 and 38, the latter figure being that also of *Lacerta vauereselli*, as well as constituting the minimum of the British Museum Elgon series of *Lacerta jacksoni*.

Supraciliary granules.—These vary in our specimens, both individually and for the two sides, between 3-3 and 6-5. They

* Cfr. Dott. M. G. Peracca. Il Ruwenzori, Relazioni Scientifiche, vol. i. Zoologia-Botanica: Rettili ed Anfibi, Lacertidae, pp. 166 & 167.

are confined principally to the posterior portion of the supraocular region. In the Ruwenzori female they are reduced to 3 on the left and to 2 on the right side. Dr. Peracca describes these as "very irregular and asymmetrical for the two sides, except in a female in which the series is a complete one on the left, but totally absent on the right side." According to Tornier, who in his description omits to quote their number, the supraciliary series of granules is incomplete also in *Lacerta vauereselli*; but, as he says, confined to the posterior portion, agreeing therefore in this point also with *L. jacksoni*.

Gular Scales.—The number of scales between the third chin-plates and the collar-plates varies between 24 and 26 in the Elgon specimens except in one, in which there are 28. This is slightly in excess of the Duke of the Abruzzi's Expedition specimens, in which they are stated to be 22. In the type of the species their number is 25.

Femoral Pores.—Their number is fairly constant, with variations between 16 and 18 in the Elgon series. In one of the two females of the Turin Museum series there is a reduction to 15–14, otherwise 17–18 being the normal number. No case of supernumerary pores occurs in any of the British Museum specimens similar to the one female quoted in this respect by Dr. Peracca.

Upper Labials (anterior to the subocular).—Except for the head of the male, made into a skull, which on its left side showed these to be 5, their normal number throughout the remainder is 4. A male of Dr. Peracca's series shows a similar variation.

Postocular and Temporal Region.—In one of the specimens the last postocular scute is in contact with the first supratemporal, similar to what is found in *Lacerta mosorensis* as figured by Méhely*. In all others it is the upper postocular and the parietal scutes which meet, as in *Lacerta horvathi* Méh. or *L. muralis* typica†.

The 3 to 4 supratemporals are exceedingly small and narrow, the first and longest being partially supported proximally by the lateral margin of its underlying postfrontal bone, and therefore visible practically in its greatest extent when the head is viewed from above.

The number of scutes for the temporal region varies greatly. Those, for instance, forming the second row between the large subocular and the first supratemporal are: 3 for the left, and 5 for the right side in the male, the skull of which served for description.

Similar variation is to be found amongst the scutes in regard to their sculpture, which shows every gradation, from the perfectly smooth through the granular stage, as pointed out in Mr. Boulenger's description of the typical specimen‡, to the faintly keeled or tubercular scutes to be met with in some of the Elgon

* *Cfr.* Ann. Mus. Nat. Hung. ii. 1904, p. 386, fig. 2, A, "Eine neue *Lacerta* aus Ungarn."

† *Ib.* fig. 2, B & C.

‡ *Cf.* G. A. Boulenger, Proc. Zool. Soc. 1899, p. 96.

specimens, a condition said by Tornier to exist also in his *Lacerta vauereselli*.

The suture between the first supraciliary and the second is slightly oblique.

The frontal shield, which also varies slightly in length, and which is especially short in some specimens, is on the whole shorter and broader than would appear from the figure on the plate accompanying the description of the type of the species. It was particularly broad in the male specimen which supplied the skull for description.

Colour-pattern and markings are quite uniform for the Elgon specimens, and identical with the type of the species. In their nearly fresh state of preservation their ventral sides were of a vivid yellow, which, since their preservation in alcohol, has changed into the whitish blue-grey described by Tornier in his *Lacerta vauereselli*, or the pale blue ascribed to the Ruwenzori female.

*Remarks on some of the supposed Specific Characters of
Lacerta vauereselli Tornier.*

On examination of specimens in a comparatively large series, as may have been seen from the foregoing, it appears that some of them are subject to individual variations.

This is particularly noticeable in the scaling of the temporal region, which was made one of the principal features by which to distinguish *Lacerta vauereselli* from *L. jacksoni*.

In the majority of specimens of the latter, these scales correspond with Dr. Tornier's description of them*, and a special note on this subject made on the male specimen—previous to resorting to the excision of the skull—was to the effect that these scales were considerably larger than those of the upper dorsals, being oblong, irregular in size, hexagonal to pentagonal in shape, feebly though distinctly keeled, and decidedly double the size of those situated immediately behind the auditory opening—all of these being the characteristics ascribed by Dr. Tornier to his *Lacerta vauereselli*, and which are also referred to by Mr. Boulenger† at the end of his description of the Ruwenzori female.

According to Dr. Tornier the collar is serrated. This, again, is a point not always easy of recognition, for some specimens show various degrees of unevenness in this respect.

The same remark applies to the number of plates forming the collar-edge, which are stated by Tornier to be 11. In the type of the species they are stated to be 10, which is the number also in one of the Elgon specimens; in the remainder of which, however, they range downward to from 9 to 7 only, thus showing considerable fluctuation. Peracca omits to quote their number.

* *Cfr.* Zool. Anzeiger, Bd. xxv., Oct. 1902, p. 702.

† "Ruwenzori Exped. Reports," Trans. Zool. Soc. vol. xix. part iii., Dec. 1909, p. 242.

Nor can I find any differences in the style of scaling of the upper dorsals between Dr. Tornier's diagnosis and that given for the type of the species by Mr. Boulenger, which scales, according to the latter, and further verified by myself, are stated to be "rhomboidal, keeled, juxtaposed, or subimbricate," every one of these conditions occurring in the Elgon specimens as well as in *Lacerta vaouereselli*.

The number of scales across the body, viz. 38 in the latter, also is in accord with the mean of the Elgon series of specimens; and, as regards the femoral pores, this has been finally disposed of, both by what has been made known (*antea*, p. 34), as well as by a remark made by Mr. Boulenger in connection with this point in his description of the Ruwenzori female.

As already pointed out in the diagnosis of the skull of *Lacerta jacksoni*, there are no teeth on the pterygoids any more than in *L. vaouereselli*. No difference appears to exist in regard to the supratemporals as described for this species by Dr. Tornier from their condition in the Elgon specimens, in all of which a small tympanic scute is plainly visible.

Neither is a distinct gular fold recognizable in all specimens, at least in the stricter sense, as it is often apparently absent in immature individuals, such as seems to be the case with Dr. Tornier's type, judging by the dimensions given by him—an assumption which is further corroborated by the fact that its sex has not been mentioned.

The length of the posterior extremity also varies greatly individually—in some Elgon examples it scarcely attains the axillary pit, whilst in others it reaches well beyond the collar-edge.

The geographical range of this species, so far as the increased, but at present still scanty, material on record permits one of judging (17 specimens, including Dr. Tornier's *L. vaouereselli*), appears to be a strictly equatorial one.

Its habitat, moreover, seems to be generally restricted to the mountainous region of that part of the Central African plateau, or immediately west of it, which culminates in its highest peaks, an area generally acquiring considerable altitude.

Its ultraplatycephalous shape, concurrently with its sombre-coloured garb, at once seems to denote a form occupying high ground, differing from those of the plains, with generally more massive skulls and more vividly contrasting colour-patterns, in the same manner as, for instance, *Lacerta mosorensis* differs from *Lacerta muralis* var. *campestris* or *serpa*, and *Lacerta muralis* var. *monticola* from the var. *bocagii*.



LACERTA PELOPONNESIACA.

J. Green del. et Chromo lith.

3. On the Peloponnesian Lizard (*Lacerta peloponnesiaca* Bibr.). By G. A. BOULENGER, F.R.S., V.P.Z.S.

[Received October 4, 1910: Read November 15, 1910.]

(Plate I.* and Text-figure 8.)

Examples of a Lizard from Greece, which had been confounded with *Lacerta muralis* or with *L. taurica*† until shown by Dr. J. de Bedriaga‡ to be fully entitled to specific rank under the name of *L. peloponnesiaca* Bibr.§, have been exhibited for the first time this summer in the Society's Reptile House. As regards coloration, the species is one of the most beautiful, and as the only figures of this Lizard we possess are quite inaccurate, or taken from specimens preserved in spirit, I requested Mr. J. Green to make coloured pictures from the specimens living in the Gardens; at the same time I seized this opportunity of drawing up a new description of this little-known Lizard, with a view to fixing its correct position in the genus *Lacerta*.

In addition to the live specimens I have had the following small series at my disposal, all except no. 3 being preserved in the Natural History Museum:—

1-2. ♂ ♀.	Morea.	Dr. J. de Bedriaga.
3. ♂.		(Lataste Collection).
4-8. ♂ ♀ hgr.	L. Stymphalos.	Norman Douglass, Esq.
9-10. ♂ ♀.	Olympia.	Hr. Lorenz Müller.
11. ♂.	Kalamata.	"

The skull of a male from L. Stymphalos has been prepared, and agrees in all essential respects with that of *L. taurica*.

Form and Proportions.

As may be seen on comparing the following table of measurements with that given for *L. taurica*||, the general proportions are the same as in that species, except for the rather longer limbs. In the male the hind limb reaches the collar or a little beyond, in the female it reaches the axil or the shoulder. The head is less flattened than in any of the forms of *L. muralis*, closely resembling in shape that of the typical form of *L. viridis*; snout sometimes very obtuse, sometimes very pointed, as long as the distance between the eye and the ear-opening; neck as broad as the head, or a little broader. The foot is always longer than the head.

* For explanation of the Plate see p. 40.

† For a description of this Lizard see P. Z. S. 1907, p. 557.

‡ Zool. Anz. 1883, p. 216, and Abh. Senck. Ges. xiv. 1886, p. 315.

§ In Bory de St. Vinc. Expéd. Sc. Morée, iii. p. 66.

|| P. Z. S. 1907, p. 563.

Measurements (in millimetres).

	♂.						♀.			
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
From snout to vent.....	80	76	76	75	71	70	77	71	70	65
" fore limb.....	32	29	29	30	28	27	28	26	25	25
Length of head.....	21	20	19	19	19	19	16	16	16	16
Width of head.....	13	13	13	13	12	12	10	10	9	9
Depth of head.....	11	10	11	10	10	10	9	9	8	8
Fore limb.....	27	26	26	25	25	25	24	21	23	22
Hind limb.....	47	45	46	42	42	43	41	35	37	34
Foot.....	25	23	24	22	22	23	21	19	22	18
Tail (*reproduced).....	170	95*	77*	100*	80*	140	105	97*	98*	125

1, 9. Greece; 2, 8. Olympia; 3, 6, 7. Morea; 4. Kalamata; 5, 10. L. Stymphalos.

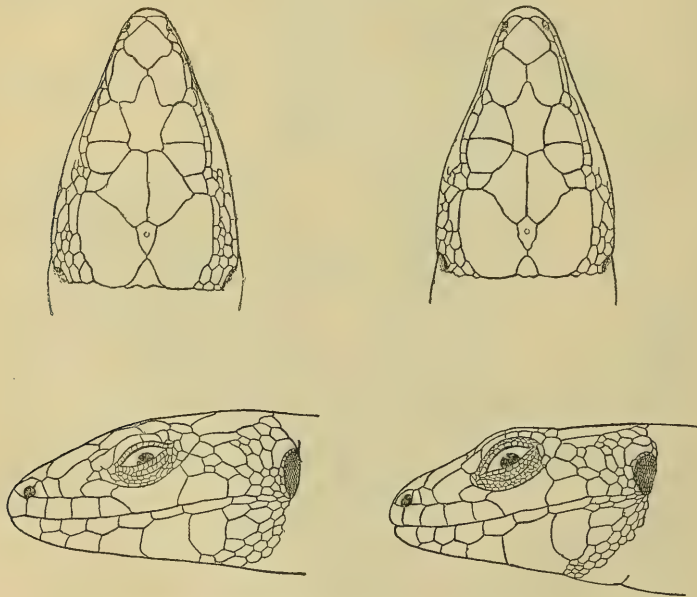
Palatal Teeth.

These are strongly developed, forming two to four longitudinal series on each pterygoid bone.

Scaling.

Rostral shield largely entering the nostril. Nasals forming a short suture behind the rostral*; frontonasal broader than long;

Text-fig. 8.



Upper and side views of head of male and female (from photographs).

frontal not longer than frontoparietals, anterior borders very concave, forming an acute angle, the shield often appearing

* In one specimen the frontonasal forms a short suture with the rostral.

trilobate in front, in adult male specimens*; parietals about once and a half as long as broad, in contact with the upper postocular; occipital very variable in size, sometimes longer, sometimes shorter, and usually broader than the interparietal, from which it may be separated† by a short suture formed by the parietals. Supraoculars in contact with the supraciliaries, rarely one or two granular scales intervening between them. Postnasal single‡. Four or five upper labials anterior to the subocular§. Rather large, irregular shields cover the temple, often exactly as in *L. viridis*; tympanic shield distinct; 3 to 5 upper temporals in contact with the parietal. 28 to 33 scales and granules in a straight line between the symphysis of the chin-shields and the median collar-plate; gular fold distinct. Collar with even edge, formed of 10 to 12 plates.

Scales on back juxtaposed, granular, round or suboval, feebly or faintly keeled, on flanks towards the ventrals larger, flat and

Table showing number of scales, plates, and femoral pores.

	1.	2.	3.	4.	5.	6.	7.	8.
♂. Greece	80	56	30	10	31	4-5	24-25	29
„ Olympia.....	76	55	28	11	30	4	23	28
„ Morea.....	76	57	28	12	28	4	20-21	30
„ Kalamata	75	60	29	10	30	5	21	26
„ L. Stymphalos	71	63	28	10	30	4	22-24	28
„ Morea	70	62	28	11	31	4-5	23-25	31
♀. Morea.....	77	59	31	11	30	4-5	22	29
„ Olympia.....	71	53	32	11	31	4-5	23	27
„ Greece.....	70	60	33	11	31	4-5	20	30
„ L. Stymphalos	65	62	31	11	33	4	24-25	27

1. Length (in millimetres) from snout to vent. 2. Number of scales across middle of body. 3. Transverse series of ventral plates. 4. Number of plates in collar. 5. Number of scales and granules between symphysis of chin-shields and median collar-plate. 6. Number of upper labials anterior to subocular. 7. Number of femoral pores. 8. Number of lamellar scales under fourth toe.

subimbricate, smooth; 53 to 63 scales across the body, 2 or 3 transverse series corresponding to one ventral plate.

Ventral plates in 6 longitudinal and 28 to 33 transverse series. Anal plate moderately large, with 2 or 3 semicircles of scales around it.

Scales on upper surface of leg a little smaller than dorsals, distinctly keeled; 26 to 31 lamellar scales under the fourth toe; 20 to 25 femoral pores on each side.

Caudal scales truncate behind, more or less strongly keeled, the whorls subequal in length.

Coloration.

This varies considerably according to individuals. Females and

* In the allied *L. taurica* the anterior borders of the frontal vary from feebly concave to feebly convex, as in *L. muralis* and its varieties. Peracca has attached undue weight to this character in his description of *L. sardoa*.

† In 4 specimens out of 12.

‡ Two regularly superposed postnasals in one specimen (♀, Morea).

§ 4 on both sides in five specimens 4 on one side and 5 on the other in six, 5 on both sides in one.

young are beautifully striped with dark brown or black, some specimens may even be described as black above with 5 or 6 light longitudinal streaks. Traces of this striation may persist in some males, but usually disappears entirely, the back being uniform brownish or dull green, with small blackish spots or vermicular lines on the sides. The figures annexed to this description will give an idea of the gorgeous colours assumed by the adult male during the breeding-season, making it one of the most beautiful of the European Lizards. The top of the head is of a reddish brown, sharply contrasting with the green colour of the nape, which gradually changes to olive or brown on the posterior part of the body; the sides of the head and body and the lower parts are of a bright vermilion-orange, relieved by a patch of azure-blue in the axillary region and a broad band of the same colour occupying the outer row of ventral shields and extending a little way up on the scaly part of the side. The female is of a reddish brown, with two broad blackish bands along each side, the outer proceeding from the eye, bordered above and below by a narrow whitish streak and separated by a third light streak which in some specimens is pale yellow, in others pale green; a small round blue spot is present above the axil; the hind limbs bear round light spots edged with blackish; the lower parts are white or pale yellow, often tinged with rosy or lilac on the sides.

Relationships.

Lacerta peloponnesiaca is most nearly related to *L. taurica*, and with it fills the gap between the massive Lizards like *L. agilis* and *L. viridis* and the forms that cluster round *L. muralis*. In its thick, convex skull and its well-developed pterygoid teeth, as well as in its temporal scutellation, it agrees with the former group, which I regard as the most generalized, whilst in its scaling and especially in its non-serrated collar it agrees very closely with the typical *L. muralis*, from which some authors have held it to be probably derived.

EXPLANATION OF PLATE I.

Lacerta peloponnesiaca, male and female, natural size.

4. Remarks on Two Species of Fishes of the Genus *Gobius*, from Observations made at Roscoff. By EDWARD G. BOULENGER *.

[Received October 30, 1910: Read November 15, 1910.]

Prof. F. Guitel, in his well-known paper on the breeding-habits of *Gobius minutus* †, remarks that the descriptions of this

* Communicated by G. A. BOULENGER, F.R.S., V.P.Z.S.

† Arch. Zool. Exp. et Gén. x. 1892, p. 499.

species by various authors vary to a considerable extent and that the fish described under this name by Collett* does not tally with the said Goby of Roscoff on which he based his observations, the number of scales along the lateral line in his specimens being about 45, those of the Norwegian fish about 60. Further that Collett's formula for the fin-rays—D. 6/11–12. A. 11—differs slightly from that of the Roscoff fish, which he gives as: D. 6/8–10. A. 8–10.

During a stay at Roscoff last summer I collected a number of specimens of the Goby described by Guitel under the name of *G. minutus* and also found there another Goby which differed at a first glance from the former in its larger size, coloration, and general appearance, and which I found on examination under a lens to have more numerous scales. This is the form described by Messrs. Holt and Byrne†, in their paper on the British and Irish Gobies, as the typical *G. minutus*, while the fish so commonly found at low tide in the pools of the shallow sandy bays of Roscoff is regarded by them as an estuarine race of the same species, to which they refer the *G. microps* of Krøyer‡ and later Scandinavian authors.

The colour of the latter fish is dorsally of a dirty grey, minutely speckled with black, laterally with large blackish blotches, which in the males usually expand into vertical bars on the side. That of the former is creamy speckled with rusty brown and with small blotches of the same colour laterally; the blotches may also form bars, which, however, are always finer and less conspicuous. I found the smaller form to be stouter than the larger, the depth of the body being usually from 5 to 6, as against 6 to 7 times in the total length, caudal fin excluded, and the scaleless area of the nape and back to be of greater extent.

These two fishes I found under quite different conditions—the *G. microps* of Krøyer close inshore, the one alluded to by Messrs. Holt and Byrne as the typical *G. minutus* at a locality north of the little island of Batz, opposite Roscoff, uncovered at the spring tides only.

From the table of particulars of the two forms, given further on, it will be seen that they differ both in number of scales and fin-rays; and there can be no doubt that the two fishes are distinct and well deserve to be regarded as valid species, not as races only.

Messrs. Holt and Byrne, however, are of opinion that a sufficient series of specimens from various localities would show a complete gradation from the one "race" to the other, and state that specimens from the Cuckmere river approach the typical form in the large number of scales and small scaleless area of the nape and

* Vidensk. Selsk. Forh. Christiania. 1874, p. 168.

† Report on the Sea and Inland Fisheries of Ireland for the Year 1901, Part ii. Appendix III. (1904).

‡ Dann. Fiske, i. p. 416 (1838–1840).

back, though in form and colour they resemble the estuarine race. I have examined several specimens in the British Museum from the Cuckmere, presented by Mr. Byrne, but find that both in appearance as well as in the number of scales they agree with *G. microps*.

It seemed desirable to make sure, by reference to the original description, which of the two species so often confounded should bear the name of *Gobius minutus*. This name was proposed by Pallas* for the fish ("*Maris Belgici*") described in a rather puzzling manner by Gronovius†, who gives the number of fin-rays characteristic of *G. microps*, while, on the other hand, the total length "*tres uncias*" (about 80 mm.) can apply only to the larger species. It is highly probable, however, that Gronovius had before him examples of both species from the Belgian coast‡, and that he noted the number of fin-rays from the smaller fish and added to his description the size attained by the larger. Gmelin's§ diagnosis "*albicans ferrugineo maculatus*, . . . D. 6, 11. A. 11" can only apply to *G. minutus* of most authors.

It is therefore satisfactory to find that no objection can be raised to the retention for the two species of the names used by the Scandinavian and other authors who have distinguished them.

The following is a tabulation of the specimens of the two species from Roscoff||:—

G. minutus.

Length.	Scales.	Fin-Rays.	
		D.	A.
55	66	VI. 12	11
53	67	VI. 12	11
53	65	VI. 12	12
53	64	VI. 12	12
50	63	VI. 12	12
49	71	VI. —	—
49	64	VI. 12	11
48	65	VI. 12	11
46	63	VI. 12	12
45	62	VI. 12	11
44	61	VI. —	11
39	63	VI. 12	12

* Spicil. Zool. viii. p. 4 (1770).

† Zoophylacium, p. 81. no. 276 (1763).

‡ Specimens of both *G. minutus* and *G. microps* from the Belgian coast were sent to the British Museum by the late Prof. E. van Beneden, and measurements of these will be found in the table at the end of this paper. The two species have hitherto been confounded by Belgian authors under the name of *G. minutus*.

§ Syst. Nat. i. p. 1199 (1788).

|| In these tables the length (in millimetres) is taken from the end of the snout to the base of the caudal fin. The scales are counted in a longitudinal series from the upper extremity of the gill-opening to the root of the caudal fin.

As will be seen from these tables, *G. microps* has 9 or 10, exceptionally 11, rays in the 2nd dorsal and anal, *G. minutus* having 11 or 12; the number of scales along the lateral line, however, shows no overlap, not exceeding 52 in *G. microps* and not falling below 61 in *G. minutus*.

I therefore hope I have succeeded in settling the question of the correct name of the fish so carefully described by Prof. Guitel, about which he rightly entertained some doubts at the time of his observations on its remarkable breeding-habits.

The two forms here discussed have been quite correctly separated and identified by Messrs. Holt and Byrne; the only point on which I cannot agree with them is with regard to the existence of connecting-links, which the examination of a large material has failed to disclose.

In concluding this note, I wish to express my indebtedness to Prof. Yves Delage for kindly allowing me to work at the Roscoff Laboratory, of which he has the direction.

APPENDIX.

Col. Shepherd, who has devoted much time to the study of otoliths, has examined for me those of the two fishes from Roscoff, and finds their claim to specific distinction confirmed by the differences in this character.

He has kindly drawn up the following notes, as an appendix to my communication:—

“Under the microscope the otolith of *Gobius microps* shows as a quadrilateral lump with fairly equal sides. Two are at a right angle, but the angle is rounded off; a third is bulged out into an outward curve, the fourth forms an indent. The three sides first mentioned are plain-edged.

“The otolith of *Gobius minutus* shows an irregular quadrilateral shape: one side is straight and plain; the other three sides are not so symmetrically shaped as in *G. microps*, and are markedly scalloped, there being six lobes on the edges of the three sides, these lobes not regularly spaced, but of varying size.

“This would show that the two fishes are different species.

“The otoliths referred to are in each instance the sagitta.”

EXHIBITIONS AND NOTICES.

November 29th, 1910.

Dr. HENRY WOODWARD, F.R.S., Vice-President,
in the Chair.

Dr. WILLIAM NICOLL, of the Lister Institute of Preventive Medicine, gave a demonstration of his method for the collection of Trematodes.

Dr. R. T. LEIPER, F.Z.S., exhibited two photographs and some specimens showing the Nematode infection known as Onchocerciasis in beef imported from Queensland.

Dr. J. F. GEMMILL, M.A., D.Sc., Lecturer on Embryology in the University of Glasgow, gave an account, illustrated by lantern-slides and specimens, of his memoir on "The Development of *Solaster endeca* Forbes," communicated to the Society by Prof. J. Arthur Thomson, F.Z.S.

This memoir will be published entire in the Society's 'Transactions' in due course.

Mr. D. SETH-SMITH, F.Z.S., the Society's Curator of Birds, exhibited living examples of the Australian Budgerigar or Undulated Grass-Parrakeet (*Melopsittacus undulatus*), showing three colour-phases. The normal bird was mostly green, with a yellow face, dark barring across the occiput and back, and blue on the tail-feathers.

The yellow variety was now common as a cage-bird, and had been known to occur in a wild state. In it the dark pigment had disappeared and practically all trace of blue had been eliminated, though some spots on the cheek, which in the normal bird were deep indigo-blue, retained a faint bluish tinge.

The third variety was an extremely rare one, in which all the yellow pigment had gone, leaving the bird almost entirely blue. Those parts which in the normal bird were green, were in this variety pale blue, while the face, which was yellow in the normal bird, was pure white.

Blue Budgerigars appeared to have been known in Belgium and France some twenty-five or thirty years ago, as they were mentioned by Greene in his 'Parrots in Captivity' (i. 117) and others of his books, and by Wiener in Cassell's 'Canaries and Cage Birds.' The variety seemed to have been entirely lost sight of, however, in this country at any rate, until M. Pauwels, a well-known Belgian aviculturist, exhibited a pair at a bird-show held at the Royal Horticultural Society's Hall at Westminster on November 25th-28th, 1910. This gentleman had several of these birds, which were said to breed true to type, but to produce a preponderance of females.

Mr. Seth-Smith pointed out that, so far, no systematic breeding experiments had been carried out with Budgerigars, but with three distinct colour-phases of a free-breeding species to work with, the material for some very interesting experimental breeding was at hand.

He acknowledged his indebtedness to M. Pauwels for the loan of the blue specimen exhibited at the meeting.

PAPERS.

5. On a Possible Cause of Pneumo-enteritis in the Red Grouse (*Lagopus scoticus*). By H. B. FANTHAM, D.Sc., B.A., F.Z.S., and H. HAMMOND SMITH, M.R.C.S., L.R.C.P., F.Z.S.

[Received October 24, 1910: Read November 29, 1910.]

The importance of Coccidiosis as a serious disease of the digestive tract of birds has lately been clearly established by Fantham in England in the case of young Grouse and Pheasants, and by Morse and Hadley in America in Fowls and Turkeys.

While pursuing our researches at the Frinley Experimental Farm belonging to the Grouse Disease Inquiry Committee during the summer of 1910, we found that out of 40 Grouse chicks hatched, 17 died between the ages of 4 and 6 weeks. These birds were examined by both of us and were found to be suffering from Coccidiosis, the parasites (*Eimeria* (*Coccidium*) *avium*) occurring especially in the duodenum and cæca. Many of these young birds, however, also presented symptoms of pneumonia, consequently the lungs, trachea, and bronchi of the birds were most carefully examined. The results of our examination were most interesting, for we both found coccidian oöcysts in the trachea, bronchi, and bronchioles. Inside these oöcysts the processes of formation of the four sporoblasts were sometimes found to be going on. The oöcysts were probably acquired by the mouth, and a few of them, instead of passing directly down the digestive tract, as is usual, may have found their way, *viâ* the glottis, into the trachea and bronchioles. It is possible that these coccidian cysts in the bronchioles would be quite capable of setting up sufficient irritation to account for the pneumonic symptoms seen in the lungs of these young birds. It would seem, therefore, that the old name of pneumo-enteritis, as applied by Mr. Tegetmeier and others to one of the diseases that caused mortality in Grouse—a view which has met with much criticism—may after all be proved to have some foundation in fact.

References to Literature.

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- Disease among young Grouse." P. Z. S. 1910, pp. 672-691, 4 plates.
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- TEGETMEIER, W. B.—'Field,' vol. 104, p. 561 (24/9/04); vol. 105, p. 1027 (17/6/05); vol. 106, p. 410 (26/8/05); vol. 107, p. 465 (24/3/06).

6. On the Alimentary Tract of certain Birds and on the Mesenteric Relations of the Intestinal Loops. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received March 1, 1910 : Read November 29, 1910.]

(Text-figures 9-28.)

For some time past I have been accumulating notes relative to the viscera of birds which have died in the Society's Gardens, and have paid special attention to the alimentary tract. In the following pages I call attention to the intestinal tract of a number of birds which either have not been studied or as to which my own investigations lead me to disagree with earlier statements.

I have dealt more particularly with such species as have not been carefully studied from the point of view of the convolutions of the intestine, and am able to call attention to a considerable series of birds. The subject is by no means a new one, dating as it does from the accurate though few observations of John Hunter. I arrive, however, at rather different classificatory conclusions from others, and venture therefore to direct the attention of the Society not only to the new facts but also to certain classificatory inferences to which these facts point.

The observations which I lay before the Society may be considered under the following headings, viz.:—

- § Historical Survey, p. 48.
- § Description of the Intestinal Tract in various Groups of Birds, p. 50.
- § Some General Considerations, p. 86.
- § The Primitive Form of the Intestine in Birds, p. 86.
- § The Course of the Evolution of the Gut, p. 87.
- § The Mutual Affinities of Avian Families judged by the Intestinal Convolutions, p. 89.
- § The Relationship between the Gut and the Nature of the Food, p. 90.
- § Summary of Facts relating to the Intestinal Coils of Birds, p. 92.

§ *Historical Survey.*

There is no doubt that the fullest general account of the intestinal tract of birds written by the older anatomists is that of John Hunter*. He examined and annotated upon more than fifty species not wholly though mainly British. His observations are entirely correct, though not always quite full enough. In many cases, however, he has seized the main features of the intestinal coils so accurately and sufficiently that but little in the way of addition is needed. Thus in the Gallinaceous birds he has appreciated the loose arrangement and absence of fixed loops in the postduodenal section of the small intestine and the attachment of its terminal region to the duodenum. In the Rails he has correctly described the three distinct loops of the jejunal region and the attachment of the first and third of these together. In the Accipitres the short loop just above the cæca is described in many forms. The peculiarities of the Parrot intestine are fully described. In short, Hunter accomplished a great deal.

Cuvier and Duvernoy † distinguished perfectly correctly, as Dr. Mitchell has pointed out, the three separate regions in the small intestine of a bird, which I propose to call duodenal, jejunal, and ileic loops, and they also indicated the fact that the middle of the three loops is frequently folded upon itself, contorted into a spiral, or subdivided into several regions. Furthermore, it is remarked (and I find myself in accord with this opinion) that, “le canal intestinal des oiseaux est loin de présenter des différences aussi nombreuses, d’une espèce, d’un genre ou d’une famille à l’autre, que celui des mammifères.” Thereafter follows a considerable amount of detail concerning these different loops in the different groups of birds. For example, the three simple loops of the Passerines are referred to in a good many species and the spiral arrangement of the middle or jejunal loop is described in the Crows. The Picarian birds, Touracou and Cuckoo, are described in such words as to show that they agree completely with the Passerines. Cuvier did not, however, as Dr. Mitchell has also and quite justly pointed out, delimit the middle region correctly. He describes the limits of the third (and last) region of the small intestine as indicated sometimes on the side of the middle loop by an unpaired cæcum (*i. e.*, Meckel’s diverticulum). This is never the case, I believe ‡.

In his ‘Lectures on Comparative Anatomy,’ Sir Everard Home § has figured the coils of the small intestine in a number of birds—for instance, the Raven, where the spiral of the jejunum and the close association of the ileic and duodenal loops are indicated; the

* ‘Essays and Observations,’ ed. by R. Owen, vol. ii., London, 1861.

† ‘Leçons d’Anatomie comparée de Georges Cuvier,’ rec. et publ. par G. L. Duvernoy, t. iv. 2me partie, Paris, 1835, p. 269 *et seq.*

‡ But see for a possible exception the account of the Tinamous below, p. 52.

§ ‘Lectures on Comparative Anatomy,’ London, 1814, vol. i. p. 402, vol. ii. pls. civ. cxvii. I am indebted to Dr. Mitchell for the exact reference to this more than once misquoted work.

Sea-mew, where the spiral is also shown, and it is remarked by the author that the turns of the intestine bear a close resemblance to those of the Crow, Swan, Goose, "*Ardea argala*," &c.—not a very long series of birds.

Owen, in describing the Flamingo *, pointed out that the small intestines "were disposed in twenty-one elliptical spiral convolutions, eleven descending towards the rectum and ten returning towards the gizzard in the interspaces of the preceding." The same anatomist correctly described the three loops in the small intestine of the Hornbill †. In the 'Comparative Anatomy and Physiology of Vertebrates' ‡ many more facts are given, most of which appear to be quite correct, but all are not quite intelligible to myself. Not many comparisons are made. The Cuckoo is correctly described, but it is not pointed out that it agrees with the Hornbill, which bird, indeed, is not referred to in the volume. The general prevalence of concentric folds among birds with long intestines is noted. The peculiarities of the Gallinaceous birds which have no fixed loops except the duodenal are appreciated in the description of the Common Fowl. The attachment of what I term the ileic loop to the gizzard and to the duodenal loop is mentioned.

Dr. Gadow's contributions § to the subject of the present communication have an importance of their own which is very great. But they do not come exactly within the limits of the discussion to which I desire here to contribute, since the aim of that anatomist was to portray the arrangement of the gut within the body-cavity and not to delimit only the permanent loops of the intestine as formed upon the supporting mesentery.

The most recent contributions to the subject known to me are by Dr. Chalmers Mitchell ||. In these memoirs, the author, in addition to discussing some parts of the subject with which I am not concerned here, deals with a much larger series of species than any previous author and has arranged his observations systematically, so as to cover most of the existing groups of birds. His special object, however, was to trace the various modifications of the intestinal tract to what he believed to be a primitive type, to arrange them in the form of a phylogenetic tree, and to see how far such a tree would agree with or correct conceptions of the phylogenetic ideas regarding birds as a whole. In the course of this paper I shall refer to various points in which my own observations do not agree with those of Dr. Mitchell. In my opinion, however, Dr. Mitchell's mode of figuring the intestinal tract of birds gives an appearance of simplicity which is misleading, with the result that birds which are separated by marked characters

* P. Z. S. 1832, p. 142.

† *Ibid.* 1833, p. 102.

‡ Vol. ii. 1866, p. 167 *et seq.*

§ "Vergl. Anatomie des Verdauungssystems der Vögel," Jen. Zeitschr. 1881. "On the Taxonomic Value of the Intestinal Convolutions in Birds," P. Z. S. 1889, p. 305; in Newton's 'Dictionary of Birds,' *sub voce* "Digestive System."

|| "On the Intestinal Tract of Birds, &c.," Trans. Linn. Soc. viii. 1903, p. 175; and an earlier paper in P. Z. S. 1896, p. 136.

are represented as being almost identical. In particular, Dr. Mitchell does not always distinguish between fixed loops, definitely formed by a narrow mesentery, and the irregular folds into which any mobile coil of the intestine may fall when disposed on the dissecting-board in Dr. Mitchell's fashion. I shall recur to definite instances in the course of this communication.

I shall now proceed to deal with the intestinal tract in a number of species of birds.

*§ Description of the Intestinal Tract in various
Groups of Birds.*

On opening the abdominal wall of most birds the intestine is usually seen to form a rather compacted mass, such as is figured, for example, by Dr. Gadow in most of the plates which illustrate his original memoir upon the intestinal tract in birds. This mass consists of parallel or concentrically arranged loops of intestine, and in the higher birds, such as a Heron, a Duck, or Stork, is very characteristic. This appearance of the gut distinguishes it at once from the Mammalian or Reptilian gut, where the intestine lies laxly within the abdominal cavity.

This also is the case with all the Struthious birds, whose intestinal tract at the first glance recalls that of a Mammal. A little disturbance of the apparently compact intestinal mass of some other birds, as, for instance, the Eagles and Hawks, shows that here, too, the intestinal tract is not really much welded together, but simply lies pushed close coil to coil, owing to the limited space in which it has to be stowed away. In other cases, however, it can be easily ascertained by the gentle pulling apart of the intestinal coils that the gut is disposed in tightly fixed loops.

This is the case, for instance, with Ducks, Storks, Penguins, and a variety of other genera and families. Inasmuch as the lax condition of the small intestine in such a bird as an Ostrich recalls that of the Mammalia and Reptiles, and is really like the intestinal tract in those Vertebrates, it is to be assumed that this condition of the bird's gut is the more primitive condition and that the specialisation into definitely fixed concentrically or parallel arranged loops, whether narrower or wider, is an index of the higher position of the bird in the series. I shall commence the following survey of such new facts as I have to add to the matter in hand by dealing with the more primitive groups of birds first. Indeed, I have not attempted in this paper to map accurately the coils in several families of birds where they are very complicated, such as the Stork tribe; for I am not satisfied as to the relationship of the coils in these birds to the more simple intestine of lower forms. It is almost entirely with the latter that I deal in the present communication to the Society.

Of the RAPTÆ I have examined all the living genera. I fully agree with Dr. Mitchell as to the basal position in this group of

Casuaris and *Dromæus*, but I find his description defective in one particular and the illustration which he gives of *Casuaris* correspondingly inaccurate. It would be inferred from that figure * that the gut lay in a single line without any attachment between the ileum and duodenum; that—to use Dr. Mitchell's own term—there was no vestige of a supraduodenal loop. The existence of this attachment is indicated by him in other cases by a cut blood-vessel; there is no such "short circuit" represented in his figure of the Cassowary. Nevertheless, two species of Cassowary which I have dissected, viz. *C. australis* and *C. westermanni*, show such a connection, which is not, however, associated with the formation of an ileic loop distinguishable from the jejunum.

Nor can I agree with Dr. Mitchell's figure of *Apteryx*, unless, indeed, the species examined by him (*A. mantelli*) differs from that examined by myself (*A. australis*). For I find in the latter bird no definite ileic loop, but only an attachment by mesentery of the latter part of the ileum to the duodenum. The bird, in fact, exactly resembles *Casuaris*, *Struthio*, and the Gallinaceous birds in this particular.

In *Rhea americana* the intestine is formed upon a plan which may be interpreted in one of two ways—one of which is certainly not "archicentric" in the sense in which Dr. Mitchell uses the word, and the other interpretation hardly justifies the use of the word "archicentric." Since, in various other points of structure (e. g. less degeneration of wing, syrinx), *Rhea* is much less "Struthious" than *Casuaris*, it might be expected that the intestinal tract also would be more like that of Carinate birds. The accompanying figure (text-fig. 9, p. 52) shows the course of the intestine in a female example of *Rhea americana*, and may be compared with the figure drawn by Dr. Mitchell † from the intestinal tract of the same species, with which I do not find myself able to agree entirely. Dr. Mitchell, however, is perfectly right in distinguishing two loops only in the small intestine, viz., the duodenal and another which may or may not be the ileic loop of other birds, or "supraduodenal," as it is termed by him.

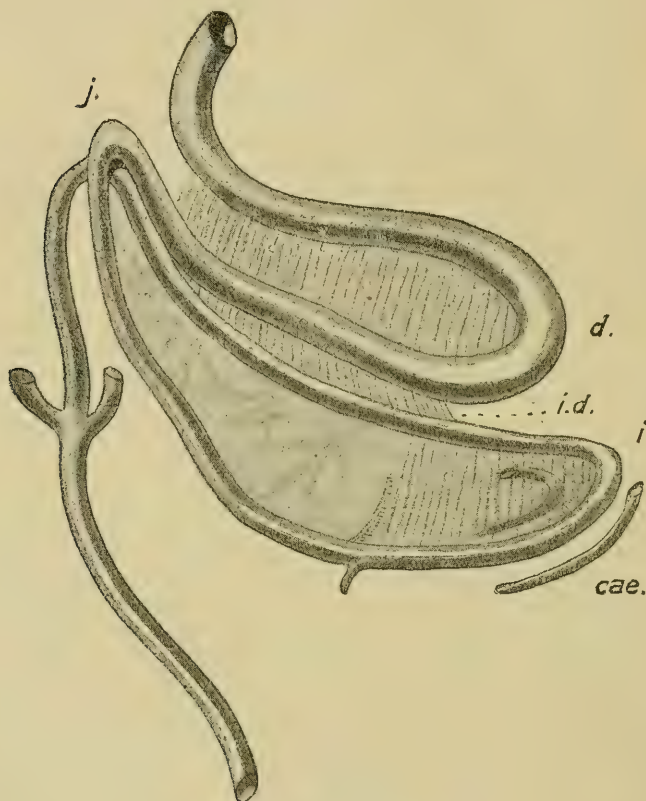
This latter loop is wider as well as longer than the duodenal loop, and it lies parallel with it as does the ileic loop (nearly always) in other birds, and is connected with the duodenal loop by the usual ileo-duodenal ligament, which is long and extends nearly to the end of the duodenal loop, while it is attached along more than half of the length of the loop now under consideration. So far the facts point towards the interpretation of this loop of the small intestine in *Rhea* as being the homologue of the ileic loop of other birds. If this interpretation be correct, then the jejunal region or loop will be practically absent and reduced merely to the small tract just where the lower limb of the duodenal loop bends round to join the lower limb of the (for the moment) alleged ileic loop. There is, I think, nothing intrinsically absurd in this

* P. Z. S. 1896, p. 140, fig. 3.

† Trans. Linn. Soc. *t. c.* p. 183, fig. 3.

suggestion; it is merely the assumption of the still further reduction of the jejunal region of the gut which is already greatly reduced in such birds as *Chunga burmeisteri* and *Houbara macqueeni*, where it is already as short as or even shorter than the ileic loop. There is another argument in favour of this interpretation of the two well-marked intestinal loops of *Rhea* which is derived from a

Text-fig. 9.

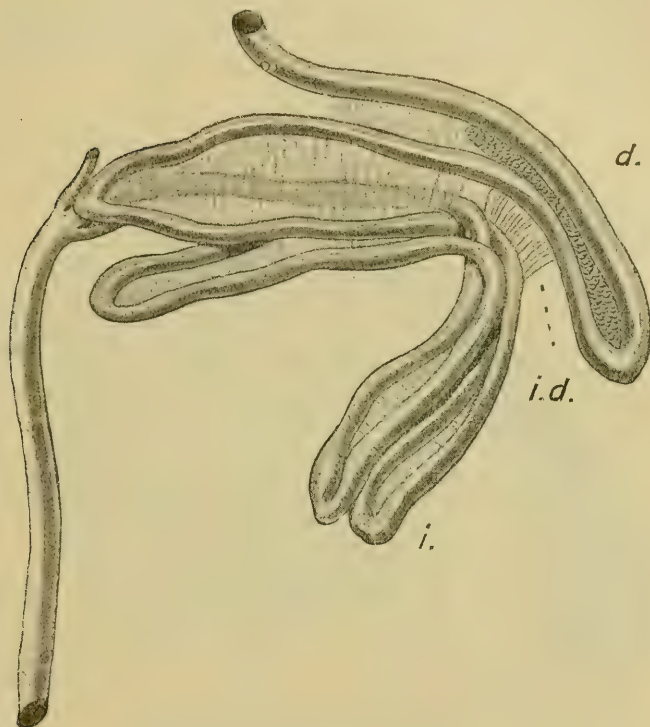
Intestinal tract of *Rhea americana*.

Cæ. Blind ends of caeca. *d.* Duodenal loop. *i.* Ileic region. *i.d.* Ileo-duodenal ligament. *j.* Jejunal region. In this and the succeeding figures the definite loops are marked by transverse lines.

consideration of the Tinamou, *Crypturus tataupa*. In the last-mentioned bird the intestinal loops are very remarkable; they are represented in text-fig. 10. There is nothing in particular to be said about the duodenal loop. This is followed by two loops, which lie one above the other, the proximal loop lying ventrally

to the more distal of the two. They are closely attached to each other and to the duodenal by ligament and cannot be freed without cutting or tearing. There is, in fact, every reason to regard these two loops as a subdivision of the usually single ileic loop. Moreover, the ileic loop is occasionally double in other birds; it is distinctly formed of two parallel loops in *Anthropoides paradisea* *.

Text-fig. 10.

Intestinal tract of *Crypturus tataupa*.

Lettering as in text-fig. 9.

It is to be noted also that the ventrally situated of the two subdivisions of the presumed ileic loop is attached up to nearly its end by ligament to the duodenal loop. There is no case known to me among birds where the jejunal loop is thus attached.

Another argument of the same kind is to be derived from a consideration of the intestinal tract of the Passerine *Ixocincla crassirostris*. In this Bulbul, of which I have dissected only one

* Vide p. 82.

example, the tract of the small intestine consists of two loops only, which are approximately equisized and are both rather wide. Furthermore, the two oval loops of gut are attached to each other along their whole length. It will be noted, therefore, that these two loops agree in all their characteristics with those of other Passerine and many Picarian Birds. But if this be so, it follows that the jejunal loop in this Passerine is reduced to the verge of disappearance. In any case, whatever be the interpretation of the several regions of the small intestine in *Ixocincla crassirostris*, it seems to me to be beyond all question that there is a very close likeness between its gut and that of *Rhea*, whether the likeness be superficial and due to parallelism of development or not.

Moreover, there is no bird known to me in which the jejunal loop has any intimate relations through ligaments with the ileic loop—at any rate, to anything like the degree which is exhibited in the case of *Crypturus tataupa*, on the view, of course, that the jejunal loop is represented. Finally—though naturally it is not attempted to lay any very great stress upon this piece of evidence—a particular relationship between the Tinamou and *Rhea* is by no means an unreasonable suggestion.

There is, however, an alternative view to be taken of the intestinal tract of *Rhea americana*. It will be observed that Meckel's diverticulum lies at about the middle of the lower limb of the loop which has been provisionally regarded as the ileic loop; the diverticulum lies nearer to the duodenum, *i. e.* above the ends of the two cæca. This fact would appear perhaps to militate against the view that has just been set forth with regard to the intestinal tract. For generally, at any rate, Meckel's diverticulum lies on the jejunal portion of the intestine and, in fact, at about the middle of the length of the entire small intestine.

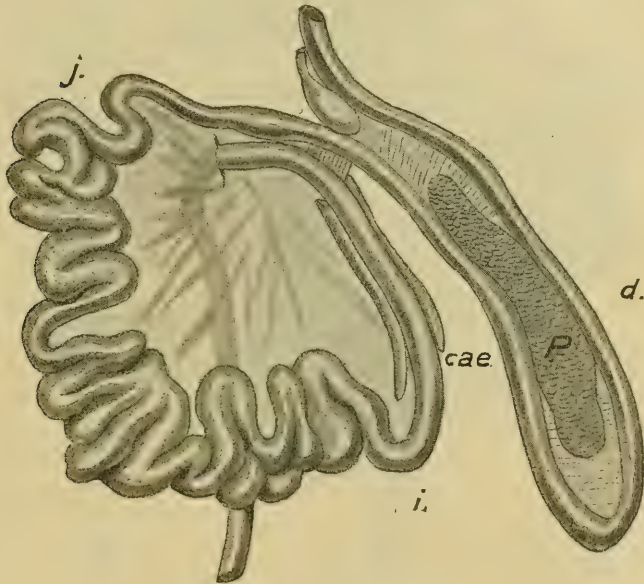
But although this may be *generally* the case in birds, it is by no means universally so. In *Dendrocygna discolor*, for example, I find Meckel's diverticulum to be very much nearer to the ileic loop than to the duodenal, *i. e.* to be not by any means in the centre of the jejunal region. This is also clearly the case with *Carpococcyx radiatus* as shown in Dr. Mitchell's figure*. There is thus no absolutely fixed position for Meckel's diverticulum within the jejunal region of the gut, though there are no positive facts which lead to the inference that this diverticulum may lie within the ileic area. If it be held that the existence of the diverticulum fixes the jejunal region of the gut, then the intestinal tract of *Rhea* is simply a slightly further development of that of *Casuarus* in the direction of the Gallinaceous birds and many Picopasserines when there is no actual loop formed in the ileic region, but merely an attachment by ligament to the duodenal loop.

The gut of the Ostrich has been described by Dr. Mitchell, as well as by others. I have only some small matters to add to the

* Trans. Linn. Soc. *t. c.* p. 243, fig. 60.

account by Dr. Mitchell in relation to the object of the present paper. The duodenal lobe of the example of *Struthio molybdophanes* has a lateral branch, as has the species examined by Dr. Mitchell. The pancreas extends down the duodenal loop to a point rather beyond this lateral diverticulum of the duodenal lobe. It does not, however, by a long way reach the end of the loop. It does, however, in *Apteryx*. The attachment of the ileum to the duodenal lobe is rather more marked than in Gallinaceous birds and much more marked than in *Apteryx*. The ligamentum ileo-duodenale reaches along the duodenal loop to a point beyond the posterior termination of the pancreas in that loop. I found no fixed loops either in the moderately long small intestine or in the longer colon.

Text-fig. 11.

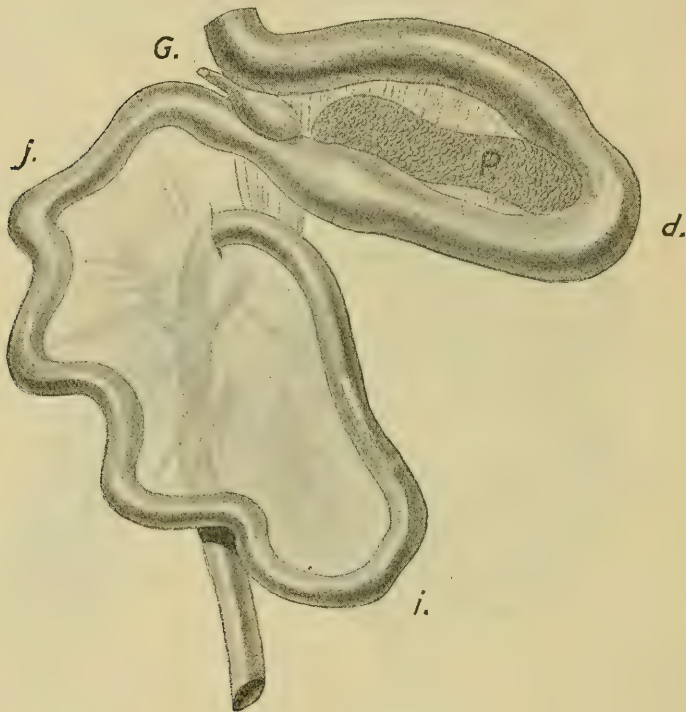
Intestinal tract of *Talegalla lathamii*.

P. Pancreas. Other lettering as in text-fig. 9.

The GALLINACEOUS birds appear to be very uniform in the structure of the gut. I may take *Crax carunculata* as a type with which the very slight divergences shown by other Galli may be compared: the duodenal loop is long and very thick and the pancreas extends about halfway down it. The duodenum soon narrows to form the jejunal region, which is of considerable length and arranged in loose folds which can be straightened out and among which are no fixed loops. There is no sharp line of demarcation between the jejunal and the ileic region, which

later becomes a straight tract of intestine running partly parallel with the duodenum and attached to it just for a short space at the root of the duodenum where it (the ileum) bends upon itself to join the colon. A second species, a hybrid *C. globicera* and *C. heeki*, was absolutely identical in all the characteristics just given. The description of one species fits the characters of the other.

Text-fig. 12.

Intestinal tract of *Ortalis ruficauda*.

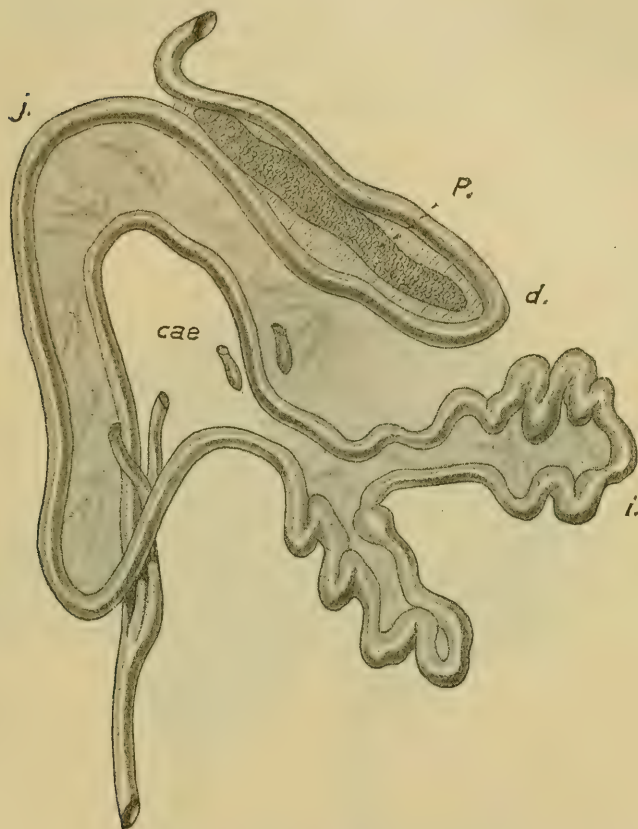
G. Gall-bladder. Other lettering as in text-figs. 9 & 11.

In *Talegalla lathamii* (text-fig. 11, p. 55) the only difference that I could detect was the further extension of the pancreas along the duodenal loop, the end of which, however, it does not reach.

Among the Phasianidæ I have examined a few species, and again find no differences of moment from other Gallinaceous birds. In *Thaumalea* (*picta* and *amherstiae*) the pancreas reaches to quite the end of the duodenal loop, and, as in other genera, the ileic end of the small intestine (there is, as in other forms, no definite ileic loop) is attached to the duodenal loop by

a not very long ileo-duodenal ligament. In *Eupsychortyx sonnini** the intestine is shorter, but its arrangement is precisely that of

Text fig. 13.

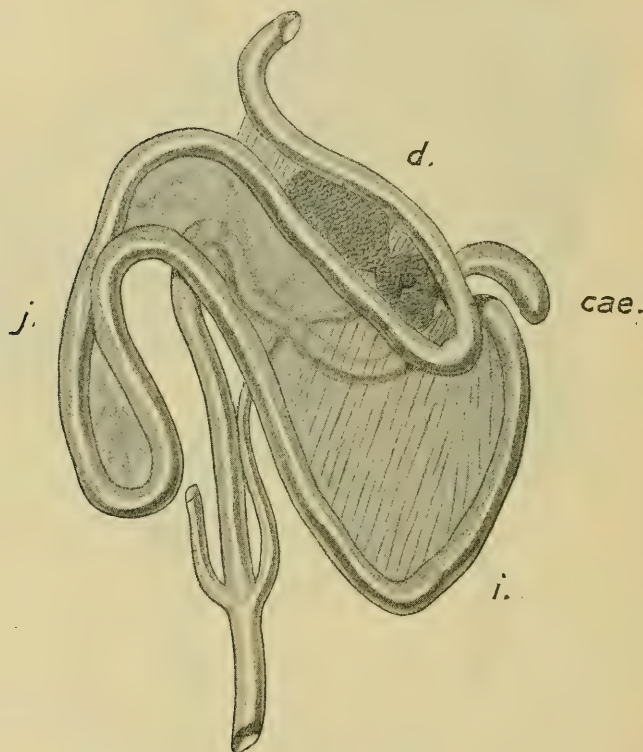


Intestinal tract of *Euplocamus nycthemerus*, showing condition reversed from the normal. Lettering as in text-figs. 9 & 11.

* The caeca of *Eupsychortyx sonnini* are remarkable in more than one way. When the body is opened these tubes are seen to lie in a tightly closed spiral or rather helicoid, producing at first the idea that it is the gut itself which is thus coiled. The spiral coiling of the caeca is not, however, permanent; they can be uncoiled and straightened with the exception of the very tip which remains coiled. Each caecum moreover, is seen to be covered with a network of bands in which a great deal of fat is laid down, and which forms a loosely meshed network with the long axis of the interstices corresponding to the long axis of the caecum. Blood-vessels traverse the strands and apparently form a corresponding network. I am disposed to compare this with the mass of short tubular blind outgrowths from the caeca in the Tinamou, *Calodromas* ('Ibis,' 1890, p. 61). A slight tightening of the bands referred to in *Eupsychortyx* would cause a bulging of the interstitial tracts and the consequent formation of such diverticula.

other Gallinaceous birds, and the pancreas extends quite to the end of the duodenal loop. *Penelope superciliaris* has also rather a short intestine and the pancreas extends to the end of the duodenal loop, thus showing that there is no distinction in this matter between the two groups of Gallinaceous birds. *Ortalis* (see text-fig. 12, p. 56) has also a very simple and short gut. I pass by a number of other genera that I have examined and which are

Text-fig. 14.

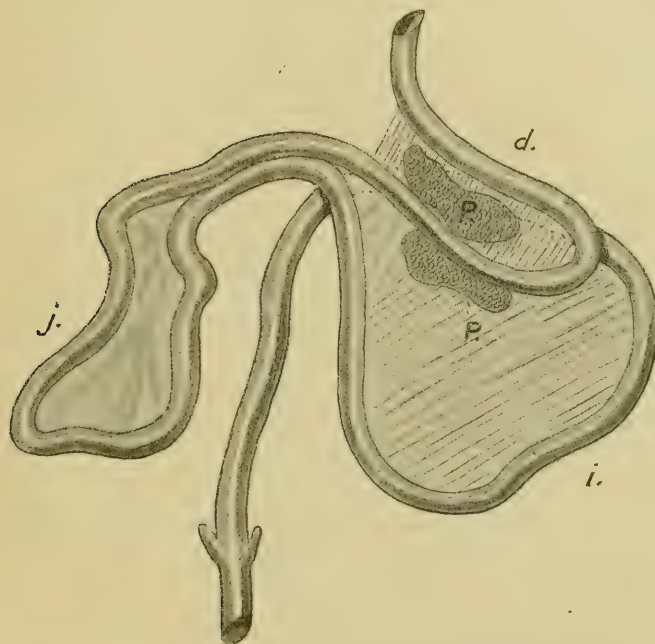
Intestinal tract of *Podargus cuvieri*.

Lettering as before.

quite like those already dealt with, to consider a remarkable variation shown by *Euplocamus nycthemerus*. In one specimen the typical Gallinaceous arrangement was to be seen; the calibre of the duodenum was much greater than that of the succeeding part of the small intestine and the pancreas extended to the very end of the duodenal loop. The terminal straight portion of the ileum was attached in the usual way by ligament to the

duodenal loop. In another specimen (text-fig. 13, p. 57) the disposition of the jejunal and ileic regions was exactly reversed*. The duodenal loop passed immediately into a straight descending limb bent sharply upon itself at its lower extremity, and then passed into a laxly coiled and rather long section of gut unattached anywhere to the duodenal loop and ended eventually in the colon. The laxly coiled region of the gut lay to the left side instead of to the right, and there was, in fact, in this individual an exact reverse of normal conditions.

Text-fig. 15.

Intestinal tract of *Gymnorhina leuconota*.

Lettering as before.

It is thus evident that the intestinal tract of the Gallinaceous birds is very uniform throughout the group and that it is constituted upon a primitive plan which is very little, if at all, in advance of that which characterises *Apteryx* among the Struthious birds. The only difference is, indeed, that the ileo-duodenal ligament is longer among the Gallinaceous birds—that more of the ileum is attached to the duodenum. But this condition is more than paralleled by *Struthio*, where, as already mentioned,

* I compare these later (p. 79) with the normal conditions occurring in *Fratercula*.

a considerable tract of ileum is attached by the ileo-duodenal ligament.

The PICARIAN BIRDS, Cuckoos, Touracous, and PASSERINES really form one group so far as their intestinal convolutions go. It is impossible, as I think, to distinguish between the Picarian *Podargus cuvieri** and the Passerine *Gymnorhina leuconota*, which may be compared and cannot be contrasted in the accompanying figures (text-figs. 14, 15, pp. 58 & 59). The salient features in these two cases appear to me to be the great width of the ileic loop (its extreme narrowness in *e.g.* the Parrots places them at the opposite end of the series) and the close mesenteric connection by the ileo-duodenal ligament of the two loops in question. The great width of the ileic loop in *Nyctidromus*, *Cypselus*, and *Trogon* can be inferred from Dr. Mitchell's figures†, though he does not, except in the case of *Cypselus*, identify the loop. These figures suggest undoubtedly the primitive gut of a Ratite or Gallinaceous bird; perhaps they are comparable with *Melanerpes*‡.

Furthermore, the total absence of specialised loops in the middle region of the small intestine is to be noted. Mitchell, as well as his predecessors in this field, has commented upon the spiral arrangement in certain Passeres, and has remarked upon the tendency to a spiral even where there is no actual regular spiral formation. This affects the middle or jejunal loop, and is greater in the Raven than in any other bird which Mitchell has described or I have examined. I found in that bird a spiral of no less than nine double turns, whereas Mitchell has figured much fewer in *Corvus capellanus*. A complete spiral of this kind is, however, not common among the Passeres. Besides the Crow tribe I know it only in the Tanager, *Euphonia violacea*. The tendency to a spiral I have observed in many Passeres, among which I may mention a number of Birds-of-Paradise which I have lately had the opportunity of studying: these are *Diphyllodes lunsteini*, *Paradisornis rudolphi*, *Paradisea raggiana*.

It seems to be universal or nearly so for the ileo-duodenal ligament to connect those two loops of the intestine along their whole lengths, and also for the pancreas to extend up to the very end of the duodenal loop. I have found both these characters to exist in *Ixocincla crassirostris* §, *Sycalis flaveola*, *Euphonia violacea*, *Graculus religiosus*, *Buceros cylindrica*, *Turdus migratorius*, *Ptilonorhynchus violaceus*, *Cassidix oryzivora*, and the first-named character in a number of other genera of which I happen to have no note as to the pancreas. Both these anatomical features seem likely to be characteristic of the Picopasseres generally, even if not universally found among the members of that order of Birds.

* I have examined two specimens of this bird.

† Trans. Linn. Soc. *tom. cit.* figs. 68, 69, 70.

‡ *V. infra*, p. 62.

§ A peculiarity of the gut of this Passerine has been already referred to, *v.* p. 53.

I have not met with many divergences among the Picopasseres from the typical structure.

One of the most abnormal types—if not the most abnormal—among the Picopasseres is the Ground Hornbill, *Bucorvus abyssinicus*. The duodenal loop is longish and the pancreas extends nearly to its end. It is perfectly free from the ileic loop, which is longer than it. The ileic loop, moreover, is indented at its free extremity and thus shows signs of being bent over upon itself. It is also considerably longer than the duodenal loop. As in other Picopasseres, the jejunal loop is more or less divided into two, and the distal loop of these two is attached to the outgoing limb of the ileic loop, which on its way to the colon is looped once in a way precisely like that shown among the Accipitres and in some other birds. These facts are particularly interesting, because they confirm current opinion as to the anatomical likenesses between the Hornbills and the Hoopoe. It is plain from Dr. Mitchell's figure * of the intestinal tract of that bird that *Upupa epops* agrees with *Bucorvus* in a number of the characters to which I have referred above. He figures the two loops of the middle part of the intestine and the small "supracæcal" loop, which latter is so characteristic a feature of *Bucorvus* as compared with other Picarian birds. He does not, however, advert to this loop by that name or compare it with the "kink" which he found in the Accipitres of both the Old and New World. Nor does he indicate a mesenteric attachment between the jejunal and ileic loops in *Upupa* such as I find in *Bucorvus*. It is impossible, moreover, to be certain from Mitchell's figure how far the ileic and duodenal loops are connected. Their entire mutual freedom in *Bucorvus* is an uncommon feature. Although Dr. Mitchell happens, as I think, to be wrong in remarking that the character of the gut does not unite the Hoopoes and Hornbills closely, he was perfectly right in making that statement from the facts before him. This is a further example of the difficulty of arriving at sound classificatory conclusions without an exhaustive knowledge of the facts.

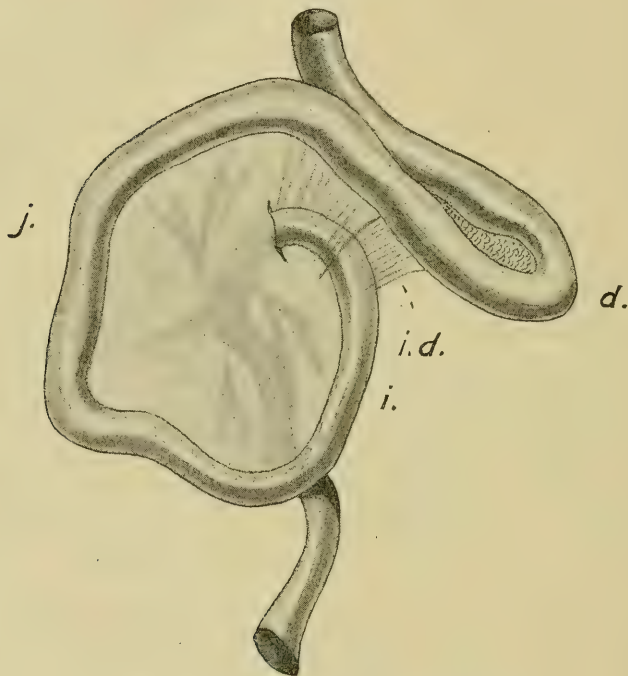
I have lately had the opportunity of examining the gut of *Upupa*, and can add something to the account given by Mitchell. It is a rather more abnormal member of the Picopasserine group than I had supposed. In my specimen there was no supracæcal kink. The duodenal loop was very wide (as Mitchell has remarked) and rather irregular in outline at its end, suggesting, therefore, a commencing spiral as in *Gypagus* and *Cathartes*—a fact which may be of some significance. The duodenal loop is larger than the ileic—precisely the reverse condition obtaining in *Bucorvus*. And while in *Bucorvus* there is no ileo-duodenal ligament, there is a short one in *Upupa* not nearly so extensive as in Picopasseres generally, and thus bridging over the gap between *Bucorvus* and its allies.

* Trans. Linn. Soc. *t. c.* p. 247, fig. 65.

The jejunum has certainly two definite loops and thus, agreeing with *Bucorvus*, differs from other Picopasseres. The pancreas in a most abnormal fashion extends into the first of these and is perhaps responsible for its formation.

It is, of course, possible that the intestinal tract of *Melanerpes superciliaris* differs from that of other Picidæ. But if it agree with that of the three species reported on by Dr. Mitchell, then I find myself in total disagreement with that writer as to

Text-fig. 16.

Intestinal tract of *Melanerpes superciliaris*.

Lettering as before.

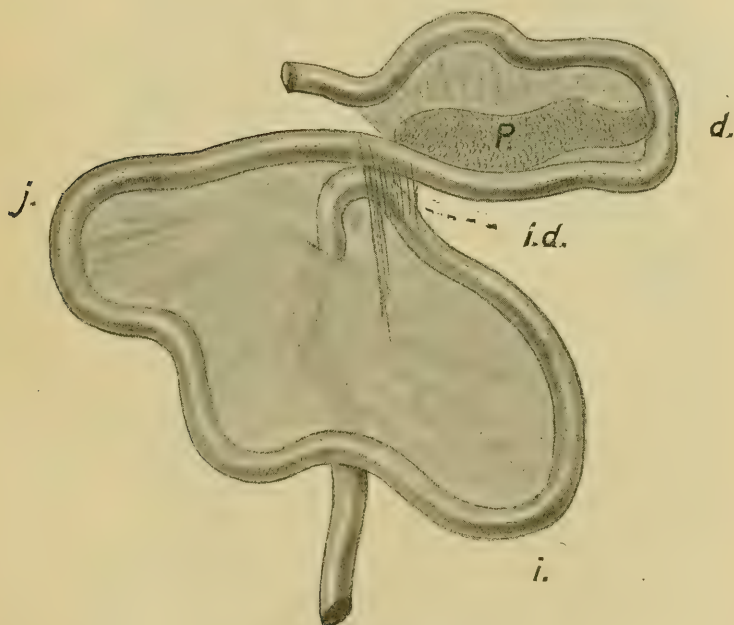
the relationships of the Woodpeckers. He observes of the Picidæ that "the conformation of the gut is in every important respect similar to that found in *Megascops*." I have not dissected *Megascops* for the purposes of the present communication, but I have examined three species of Toucans, of which family (Rhamphastidæ) Dr. Mitchell remarks that "Meckel's tract and the short rectum do not differ from the form found in *Megascops*." Now in *Megascops asiatica*, as is plainly shown in

Dr. Mitchell's figure *, there is a distinct ileic loop, which is wide as in Picopasserres generally. In the Toucans *Aulacorhamphus sulcatus*, *Rhamphastos ariel*, *Rh. carinatus*, there is also a perfectly distinct ileic loop a little less distinct than in some Picopasserres, but still distinct.

In *Melanerpes superciliaris* the only properly marked intestinal loop is the duodenal, down to the very end of which extends the pancreas. There is absolutely no ileic loop, as is shown in the figure (text-fig. 16). The jejunum simply passes forward and is connected by ligaments with the gizzard and with the duodenum quite far from the free end of the loop; it then turns abruptly backwards, passing straight to the cloaca.

The arrangement of the gut is, in fact, precisely that of the Gallinaceous birds, though, of course, the gut is shorter than that of most.

Text-fig. 17.

Intestinal tract of *Gecinus viridis*.

Lettering as before.

There is, indeed, no great disparity in length between the gut of *Melanerpes* and that of an equisized Gallinaceous bird, such as *Coturnix chinensis*. In view of the primitive nature of the palate as urged by Huxley and Parker, though not held by some

* Trans. Linn. Soc. *tom. cit.* fig. 71, p. 233.

others, the existence of a primitive type of gut is not without interest. There is in any case no doubt about their difference in this respect from their supposed allies the Rhamphastidae, though it remains to be seen whether they are like Picarian birds of any other groups. These facts and considerations gain additional significance from the quite similar intestinal tract of *Gecinus viridis* (see text-fig. 17, p. 63).

Opinions undoubtedly differ as to the generic subdivisions of the family Alcedinidae, but *Alcedo ispida* and *Halcyon sancta* have been placed in different genera—whether *Halcyon* or *Sauropatis*. The intestinal tract is, however, rather different in these two species, though one may be considered to be an exaggeration of the other. The simpler of the two is that of *Alcedo ispida*. In this Kingfisher the duodenal loop is free from the ileic for at least the greater part, and thus contrasts with most other Picarian birds. The jejunal region lies in a short spiral; but this spiral is not a permanent structure. It can be easily disarranged and spread out into an irregularly shaped loop. There is, in fact, no mesenteric connection between the circles of the spiral. The ileic loop is large, wide, and somewhat irregular, fully as long as the duodenal loop. The spiral of the jejunal region is, it should be added, quite a short one with only two complete turns.

In *Halcyon sancta* there are differences in nearly all of these features. The duodenal loop is, however, the same; it is a simple loop, not particularly wide, and the pancreas extends along it quite to its free end. I omitted to make any notes about the pancreas of *H. vagans*. The jejunal region of *Halcyon sancta* forms a spiral of eight limbs, and is thus, in the first place, much more complex than that of *Alcedo ispida*. In the second place, this spiral is fixed, and is a perfectly permanent structure which cannot be unwrapped without tearing the connecting sheets of mesentery. These are two important differences from the spiral found in *Alcedo ispida* and are, indeed, much greater differences than are known to me to exist between two species of any other genus. The condition of the jejunal section of the small intestine does not, however, exhaust the differences which eventually distinguish these two species of Kingfishers.

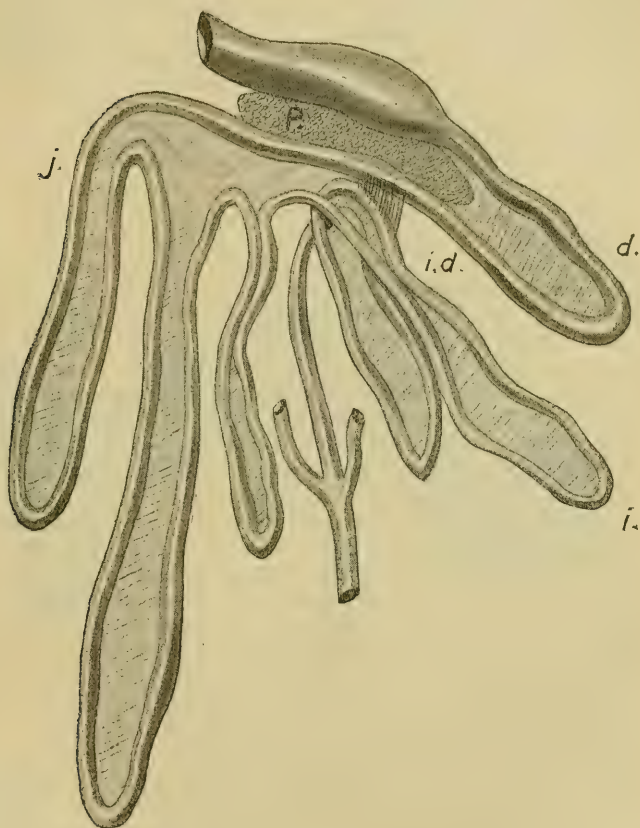
The ileic loop is, as in the last species, quite free from the duodenal; there is no ileo-duodenal ligament, except perhaps at the very base of the otherwise mutually free loops. The loop is, however, double, as it is, for example, in *Grus japonicus**, and as is shown in text-figure 18. Of these two loops, the proximal is the larger and is wide and somewhat irregular in form, and of about the same length as the duodenal. On the whole, it may, as I think, be admitted that the difference which the alimentary tract of this Picarian bird shows from that of other Picarian birds is actually greater than that which exists

* *Vide* p. 82.

between the Limicoline *Recurvirostra* and such a Passerine as *Euphonia*—in this case, two entirely different groups of birds.

Among the CUCULI I have examined only *Eudynamis orientalis*, which is one of the genera which does not seem to have been examined by previous writers from the present point of view.

Text-fig. 18.



Intestinal tract of *Grus japonicus*.

Lettering as before.

So far as I am able to say from the examination of this one type, Miss Marshall's figure* of *Geococcyx californianus* is a better representation of the characters of this group than that given by

* "Studies in Avian Anatomy.—II.," Trans. Texas Ac. Sci. ix. 1906, pl. ii. fig. 22.

Dr. Mitchell*. For the jejunal region possesses no definite loops and the gut, as a whole, is entirely like that of the majority of the Picopasseres. In *Eudynamis orientalis* the pancreas extends to the very end of the duodenal loop; the ileo-duodenal ligament also extends in its attachment to nearly the end of the duodenal loop. The ileic loop is, however, longer than the duodenal. In the jejunal region there are no specialised loops, and this part of the gut shows indications of a spiral arrangement.

Of the Musophagidæ I have examined two examples of *Turacus macrorhynchus* and one of *T. buffoni*. The two individuals of *T. macrorhynchus* agreed absolutely; the gut of *T. buffoni* differed very slightly from that of its congener. In *Turacus macrorhynchus* the duodenal and ileic loops were closely connected throughout their whole length by an ileo-duodenal ligament. The loops were moderately wide and of equal length or very nearly so. The jejunal loop is a little longer than either of the others and has a slight tendency to a spiral; when straightened out forcibly it lies in a Y shape with some slight rotation, as Hunter has figured in the case of *Scythrops novæ-hollandiæ*†. The pancreas, it should be observed, extends down to the very end of the duodenal loop. The only difference that I could detect in *Turacus buffoni* is that the ileic loop is rather longer than the duodenal. It is clear that the intestinal tract of these birds is precisely like that of the Cuckoos and of the majority of the Picopasseres.

Of the group HEMIPODII or TURNICES I have dissected two examples of the species *Turnix varia*. They were quite identical in the convolutions of the intestinal tract. The duodenal and the ileic loops were attached up to the end or very nearly so by an ileo-duodenal ligament. The loops were also fairly broad. The jejunal region of the gut lying between these two loops at either extremity of the canal was formed of a single loop, which had a tendency to twist itself into apparently two loops; but, without tearing or in any way interfering with the mesentery, this part of the gut could be moulded into the characteristic Passerine plan, as is shown in the accompanying figure (text-fig. 19). The pancreas extends right to the end of the duodenal loop. It is obvious from what has been said that this bird has a typically Passerine gut. It has not the faintest likeness to any Gallinaceous bird. Its likeness to many Passerines is shown by the fact that the pancreas extends down to the very end of the duodenal loop, and also by the breadth and connection up to the very end or nearly so of the ileic and duodenal loops as well as by the slightly spiral, and limited, jejunal loop.

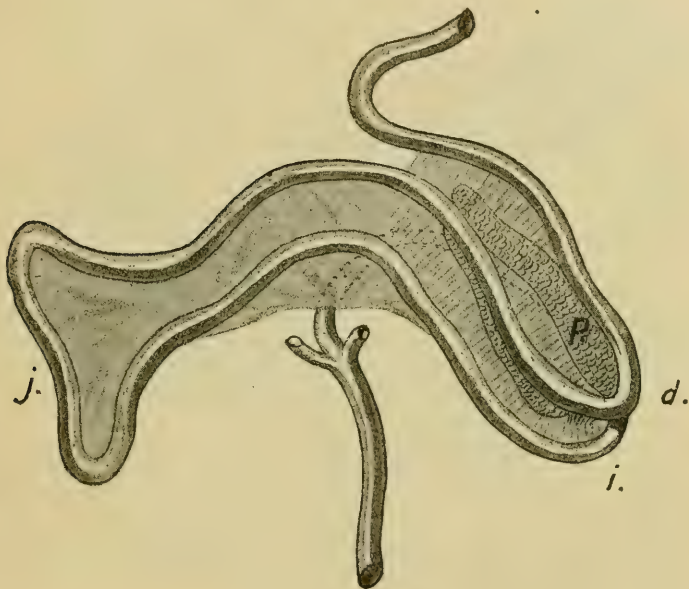
ACCIPITRES.—Among the Accipitrine birds which have not been examined by Dr. Mitchell I have dissected the Harpy Eagle, *Harpyhaliaëtus coronatus*. The duodenal loop is moderately wide and the pancreas does not extend far down it. The ileic loop is also fairly

* *Loc. cit.* p. 242, fig. 60.

† 'Essays and Observations,' vol. ii. p. 286.

broad, and contrasts very markedly with the duodenal loop, on account of the small calibre of the intestinal canal in this region; the duodenum is particularly wide and tapers off gradually towards the jejunum, the greater part of which is also very narrow; the tube is, in fact, quite as narrow here as is the ileum. The contrast between the duodenum and the commencement of the jejunum on the one hand, and the rest of the jejunum and the ileum on the other hand, is remarkably like that seen in the Gallinaceous birds, e. g., *Crax* (see p. 55). The ileic loop is as long as the duodenal loop or very nearly so. It is connected to it by a very short ileo-duodenal ligament, which leaves almost the whole of

Text-fig. 19.

Intestinal tract of *Turnix varia*.

Lettering as before.

both loops free of each other. The jejunal region is of considerable length, and lies loosely and irregularly folded in the body-cavity for the most part. The commencement of this part of the intestine, however, where it joins the duodenum is not only, as already mentioned, of greater calibre than the rest, but is fixed in a short and wide and therefore not very well-marked loop. The rest of this section of the intestine lies loosely like the Mammalian small intestine or the jejunum in Gallinaceous birds—that is to say, it has no fixed loops, but can be passed in a straight line between the fingers without tearing or distorting the mesentery which

supports it. Finally, between the ileic loop and the colon is a well-marked supracæcal fold, found in all Accipitrine birds and in some others. Of other Falconidæ I have examined the following species, which are not referred to in the memoir by Dr. Mitchell, viz. *Geranoaëtus melanoleucus*, *Astur palumbarius*, *Tinnunculus alaudarius*, *Astur approximans*, as well as one or two species that are referred to by him.

In *Astur palumbarius* and *A. approximans* the gut shows no marked differences from that of *Harpyhaliaëtus*, which I have taken as the type for this group. The pancreas extends but a short way along the duodenal loop, and the ileic loop is attached to the duodenal by a short ligament only at the base. The supracæcal loop is present, and the jejunum cannot be said to possess any pronounced folds independent of each other. As it lay in the body I noticed the formation of spirals in this region of the gut in *A. palumbarius*; but these were not permanent formations as in *Recurvirostra avocetta*. The whole of the jejunum could be straightened out bit by bit, the most pronounced fold, close to the duodenum, being large and wide and hardly comparable to the definite folds in the jejunum of more specialised birds, such as the Psittaci. *Geranoaëtus melanoleucus* shows again no salient differences; the supracæcal fold, however, is nearly as long as the ileic loop.

I agree with Dr. Mitchell in regarding the gut of *Falco* as being aberrant when compared with that of other Hawks and Eagles. The duodenal loop is, as he has said, irregular in form. I may add that the pancreas extends a good deal further down the duodenal than in the other Accipitres hitherto dealt with in the present communication. Even the ileo-duodenal ligament is a little more extensive than it is in *Astur* &c.

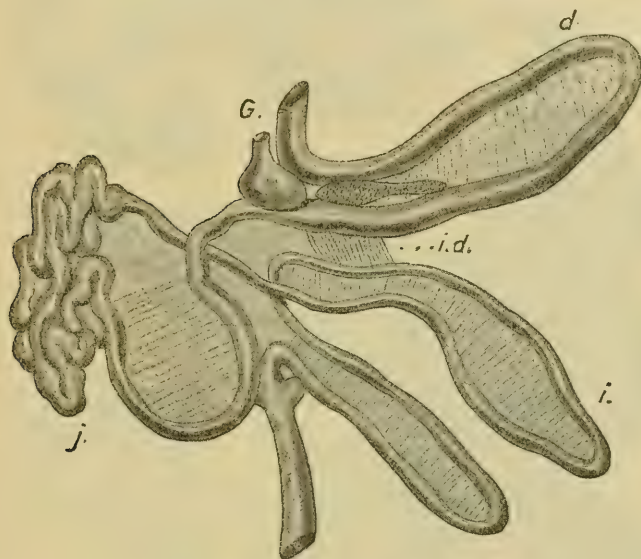
In *Tinnunculus alaudarius* there is an exaggeration of the "abnormality" of the duodenal lobe, which is almost bent upon itself in a spiral fashion. In this Hawk the greater part of the jejunum is disposed in a temporary spiral coil; but the first part of the jejunum is in the form of a single loop, which is comparable to that figured by Mitchell in *Falco**, and which I have described above in *Harpyhaliaëtus*.

Spizaëtus bellicosus (see text-fig. 20) is another species upon which Dr. Mitchell had not the opportunity of reporting. It agrees with other Accipitres in its general characters, but there are some minor points of difference. Thus, the disposal of the jejunal is exactly what we find in *Harpyhaliaëtus coronatus*. This region of the gut commences with a very wide stiff loop and then passes into a loosely folded length of tube. The ileic loop is rather longer than the duodenal, and the supracæcal kink is developed into a loop nearly as long, the two together reminding us of the double ileic loop of the Cranes and even the Tinamous.

* In both of two examples of *Falco peregrinus* I have not seen a marked loop corresponding to this. The jejunum lay entirely or mostly in a rough spiral, which could be arranged in an irregular circular fold.

I have dissected one example of the New World Vulture, *Gypagus papa*, whose intestinal tract I am able to compare with that of *Cathartes aura* described by Mitchell. In view of the fact that the American Vultures have been regarded by many systematists as being quite remote in their affinities from the Old World Vultures, indeed from the Accipitres generally, it is very important to bring together all contributions that are possible towards settling this vexed question. The duodenal loop differs from that of *Cathartes* and is, indeed, quite like that of *Falco feldeggii* figured by Mitchell*. The distal extremity is folded over

Text-fig. 20.

Intestinal tract of *Spizaetus bellicosus*.

Lettering as before.

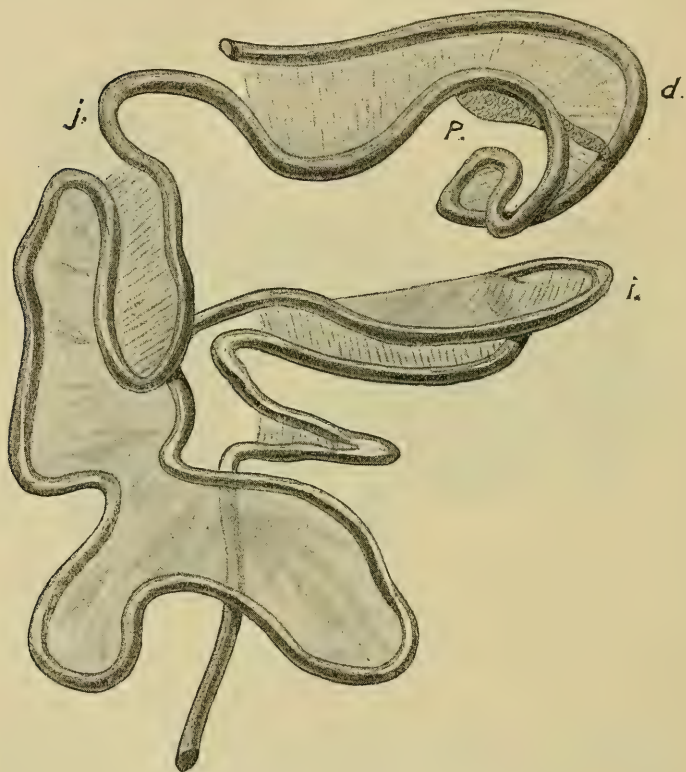
upon itself in a fashion that does not appear to occur among Picarian birds. The jejunal loop is arranged in a spiral fashion like many birds, including, however, *Tinnunculus*, in which *Gypagus* appears to differ from *Cathartes*. The ileic loop is simple. The kink so characteristic of Accipitres (but also found in other birds, including *Bucorvus*) above the position of the caeca in other birds is present as in *Cathartes*. It is not, in fact, possible to locate *Gypagus* definitely in the system.

I have also examined *Cathartes aura* (see text-fig. 21), and in most matters I am able to confirm Mitchell, as will have been

* Trans. Linn. Soc. *t. c.* fig. 33, p. 211.

inferred from what has been already said about *Gypagus*. The spiral of the duodenum makes rather more than a complete circle and its limbs are fixed together by mesenteries; the gut does not simply *lie in* a spiral. The loop which is lettered "l" in Mitchell's figure is broader and not so narrow according to my observations, but better marked than in *Gypagus*. As to the following portion of the small intestine, I do not agree in detail with Mitchell.

Text-fig. 21.

Intestinal tract of *Cathartes aura*.

Lettering as before.

The two loops forming it run close together, so that it is long and narrow, and not broad as figured by Mitchell. There is a tendency to form a rough kind of spiral not nearly so marked as in *Gypagus*. The ileic loop is only attached to the duodenal by mesentery at its very base. The supracæcal loop is more marked than in *Gypagus*.

STRIGES.—Among the Owls, I have examined *Scotopelia bouvieri*, which has not yet been investigated from the present point of view. The duodenal loop is widish and there is no trace of an ileo-duodenal ligament—in fact, the ileic loop lay on the right side of the body. The ileic loop is quite simple and is about as long as the duodenal. The jejunum shows three quite distinct loops; the first of these, *i. e.* that immediately following upon the duodenum, is wider than, but of about the same length as, another short loop which immediately follows it. A third loop of greater length has a distinct hint of spiral twisting. In *Syrnium aluco*, *Asio otus* (see text-fig. 22), *Strix perlata*, *Ninox boobook*, *Bubo maximus*, *B. virginianus*, *B. maculosus*, *B. cinerascens*, and *Strix flammea*, the ileic and duodenal loops are connected by a ligament which extends about halfway along the former loop. The difference is rather extraordinary in the matter of this ligament between *Scotopelia* and other genera, and it is, of course, possible that we have to do with an individual variation of *Scotopelia bouvieri*.

Text-fig. 22.

Intestinal tract of *Asio otus*.

Lettering as before.

The division of the jejunal tract of the small intestine into separate loops is not always well marked. In *Bubo maculosus*, for example, there are no fixed folds whatever between the duodenal and ileic loops; the whole of the jejunal region is like that of the Gallinaceous birds or the Mammalia, and can be passed through the fingers in a straight line without rupturing or even straining the mesentery. The same statement applies to *Bubo cinerascens*, of which species I have dissected two examples. I noticed here that the undisturbed jejunum lay in slight spiral coils; but these were

in no way permanent structures, but could be readily pulled out straight. In *Bubo virginianus* the greater part of the jejunum lies in the same way in loose movable coils; but there is a hint of a fixed loop—wide and shallow—at the commencement of the jejunum. *Bubo capensis* (I have seen two examples) and *B. maximus* were quite like *B. maculosus* and *B. cinerascens*, a slight and quite unfixed spiral being particularly noticeable in the case of the first-mentioned species.

I quite agree with Dr. Mitchell that *Strix flammea* has a jejunum which may be regarded as archicentric. I cannot, however, understand why Dr. Mitchell should emphasise the archaic character of the gut of this Owl by terming it “remarkably archicentric” and by figuring a state of affairs* which is not at all archicentric. For, in his figure of *Strix flammea*, there is correctly represented a well-marked “supraduodenal fold”—or ileic loop, as I prefer to call it—and a definite loop in the jejunal region. The latter I did not find in that species of *Strix*; but I am not at all disposed to dispute the accuracy of Dr. Mitchell’s figure. For in *Strix perlata*† the jejunal fold is disposed in three more or less equisized and not very close loops; but still they appear to be definite loops, and the jejunum is not merely a loose coil as in *Bubo*. This species is therefore not at all archicentric.

The conditions seen in *Strix perlata* seem to me to be a slight exaggeration of those which I noticed in *Strix punctatissima*. In the latter Owl the jejunum is formed by a tube which lies in the undisturbed intestine as a spiral. It can be smoothed out without tearing any mesenteric connections into the not circular but rather W-shaped coil so characteristic of Passerine and many Picarian birds; the rest of the small intestine is of less calibre and becomes suddenly so; it again lies in the body in a spiral fashion, but can be smoothed out in the same way into a broad but rather irregular ileic loop. The ligamentum ileoduodenale extends nearly to the end of this and is attached to about halfway down the duodenal loop. The pancreas extends for rather more than halfway down the duodenal loop. The gut of this genus is considerably shorter than in, for instance, *Bubo*, and is to be contrasted by its stiffness with the lower coils of the latter.

Athene noctua, being a small species, might be expected to show those differences from other Owls which are often met with in comparing small species with larger allies. As a matter of fact, the jejunal region of the gut is comparatively short and shows no trace of any fixed loop such as occurs in some other Owls. In this species the pancreas extends to the very end of the duodenal loop; in a species of *Ciccaba*, in *Strix flammea*, *Asio otus*, *Ninox boobook*, *Bubo maculosus*, *B. cinerascens*, *B. virginianus*, and some other Owls, the pancreas does not extend so far

* Trans. Linn. Soc. t. c. fig. 66, p. 248.

† It is not certain how far these alleged species of *Strix* have that value.

down the duodenal loop, but it is longer than in the Accipitres. This fact, indeed, and the rather greater extension of the ligamentum ileo-duodenale, is the chief difference that distinguishes the Owls from the Accipitres, the general plan of the gut in these two subdivisions of birds being otherwise similar in many ways.

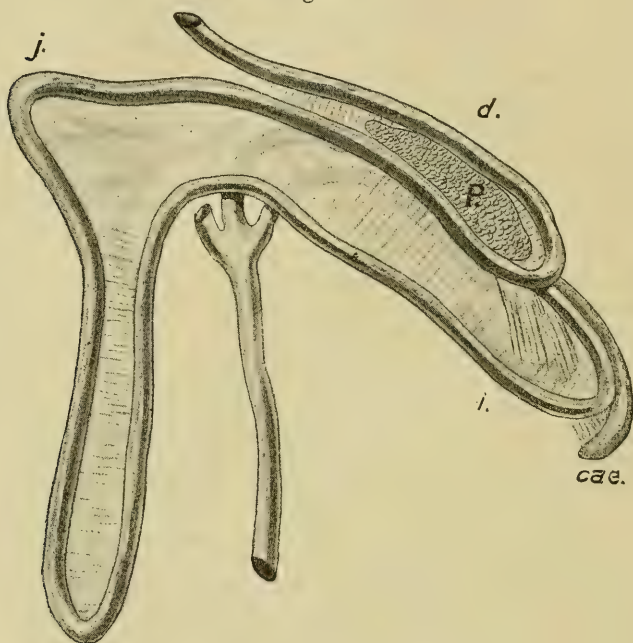
The groups that have been hitherto considered, viz. the Ratitæ, Galli, Hemipodii, Picopasseres, Cuculi, Musophagi, Accipitres, and Striges, agree with each other in that the jejunal region of the gut, though it may vary greatly in length, is never thrown into much marked fixed loops, such as those which characterise the groups of birds that remain to be dealt with. There is, indeed, the commencement of the formation of such loops to be seen in the Accipitres and Striges; but they do not arrive at the perfection and complexity of interconnection which is exhibited in the remaining families of Birds. Among the latter, however, with which I shall proceed immediately to deal, there are species and even genera which show the simpler conditions of the jejunum that characterise the families of Birds already dealt with—for instance, in *Pluvianus* among the Limicolæ and in the Bustards and Cariamidæ. In the latter the simple conditions look like reduction; while in *Pluvianus* we may have to deal with an archaic representative of its family which has not yet cast off the comparatively primitive type of gut.

ALCTORIDES.—The Bustards are an example of a well-marked family of birds which show a great uniformity in their intestinal tract. The species which I have myself examined are *Eupodotis australis* and *Houbara macqueeni*, and they evidently agree with *Otis tarda* as described by Mitchell*. In *Houbara macqueeni* the duodenal loop is attached to the ileic by a ligament which extends to the very end of the former; the ileic loop is considerably longer than the duodenal. The pancreas extends as far as the very end of the duodenal loop. The jejunal region is formed of a single fixed loop, which is not quite so narrow as is depicted in *Otis tarda*. *Eupodotis australis* (see text-fig. 23) has an intestine which is so like that of *Houbara* that I can find no fresh terms in which to describe it. Of birds admitted to be possibly allied to the Bustards, that which most closely resembles the two genera just referred to is *Chunga burmeisteri*. The resemblance, however, does not quite reach, though it very nearly approaches, identity. In this bird the duodenal loop is, as in the Bustards, shorter than the ileic. But the ileo-duodenal ligament stops about halfway along the duodenal loop, though extending further along the ileic. A point of likeness to the Bustards is the extension of the pancreas to the end of the duodenal loop. The jejunal region of the gut is also like that of the Bustards, in that it consists of but one loop which occupies the whole region, of which, in fact, this section of the intestine solely consists. Here we have an obvious

* Trans. Linn. Soc. t. c. p. 226, fig. 45.

likeness to the Bustards. The loop differs, however, in being considerably wider than it is in the Bustards. These birds form together a part of Mr. Sclater's Order Alectorides, and, as they obviously agree together very closely in the characters of the gut, I deal with these provisionally under that name; for there is, at any rate, no very general agreement as to their position among related groups and their affinities with each other.

Text-fig. 23.

Intestinal tract of *Eupodotis australis*.

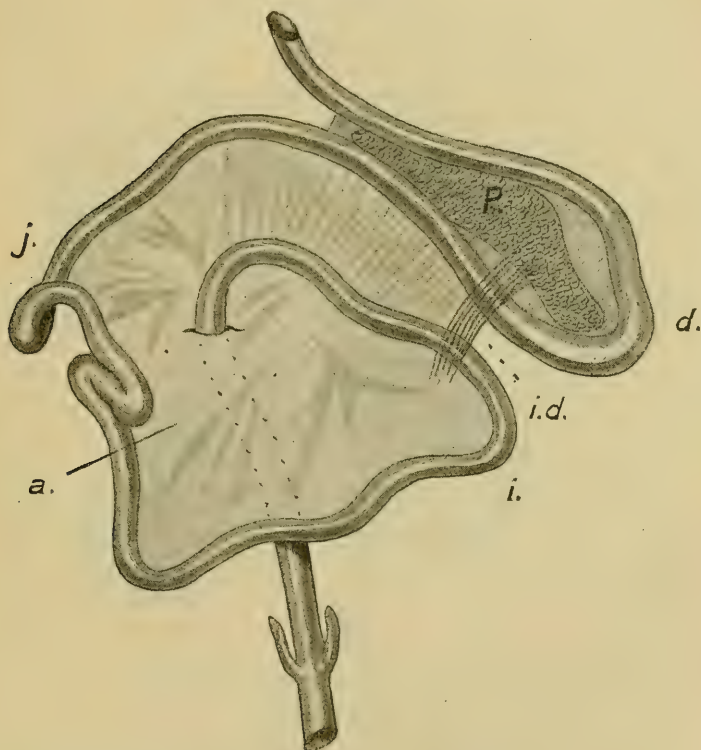
Lettering as before.

Among the LIMICOLÆ, with which, as I think, the Gulls and Terns are obviously to be placed, there are several variations to be seen in the coils of the alimentary tract. The most primitive form of the alimentary tract known to me among those birds is shown in the case of *Pluvianus ægyptius*, for reasons which I shall indicate after describing the facts. The duodenal loop is fairly wide and the pancreas extends back to the very end of that loop. The jejunum is not definitely distinguishable from the ileum, but the whole length of the small intestine, before it bends upon itself to form the straight region which bears the small and Passerine cæca, is loosely disposed as in Gallinaceous birds. The last part of this jejuno-ileic region runs, as in Gallinaceous

birds, parallel with the duodenal loop and is attached to it by an ileo-duodenal ligament, which extends nearly to the end of the duodenal loop. It is, as I think, possible to interpret this intestinal tract in only one way, and that is as follows.

It has been compared with that of a Gallinaceous bird, and this is really tantamount to saying that in the coils of the intestinal tract *Pluvianus* presents us with archaic characters. After the duodenal loop there is no marked differentiation of the gut

Text-fig. 24.



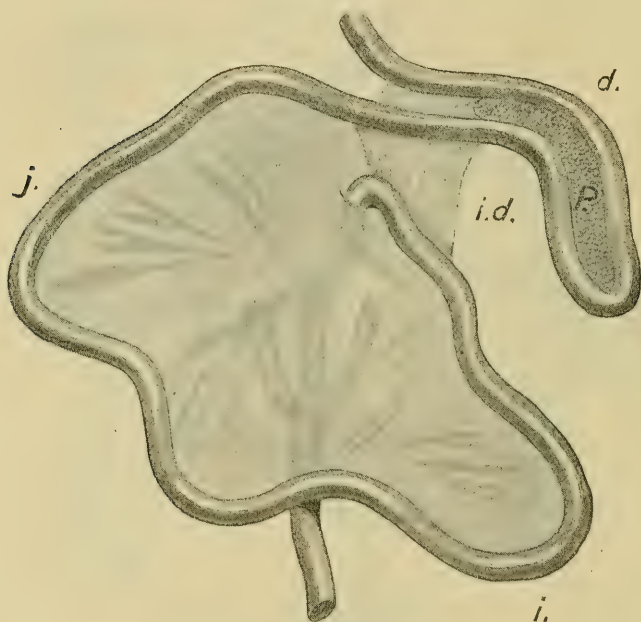
Intestinal tract of *Pluvianus aegyptius*.

Lettering as before.

into special loops at all. There is, however, as it appears to me, an indication of an advance upon the condition of the gut which characterises the Gallinaceous birds and in the direction of some other Limicolous birds. In the Gallinaceous birds the distal extremity of the small intestine is straightened out, but it is relatively only a small part of the jejuno-ileum which is thus

differentiated from the much longer coiled region. Now, in *Pluvianus* the distal portion of the jejuno-ileum can be *de rigueur* divided off from the point lettered *a* in the figure (text-fig. 24), after which point the intestine exhibits no resting in loose folds, but passes in a broad curve to the point where it is attached by a ligament to the duodenum. We have, in fact, here the commencing separation from the jejunal region of a very wide ileic loop. There is, in fact, a close similarity with the gut of *Melanerpes* *. A slight alteration in the gut of both of these

Text fig. 25.

Intestinal tract of *Ædicnemus scolopax*.

Lettering as before.

birds leads to that of many Picopasserres, where the ileic loop is more definitely marked off from the jejunal but remains very broad. From this type, moreover, can be readily deduced the plan of intestinal coiling which is found in some other Limi-colous birds which I have examined. One of the simplest of these is *Sarciophorus pectoralis*, in which the ileic loop is attached to the duodenal for nearly its whole length by the usual ligament and is also a wide loop. The jejunal has no fixed loops, but lies

* Vide p. 62.

in rather stiff coils, which approach a spiral; there are about three of these, so that the gut is not long. It is quite difficult to differentiate this gut from that of most Picopasseres. *Edicnemus* (*E. scolopax* and *E. grallarius*) hardly differs from *Sarciophorus*. Of this genus I may, in the first place, remark that the pancreas extends back to the very end of the duodenal loop. The attachment of this loop to the ileic is as in *Pluvianus*. The ileic loop, moreover, at any rate in *Edicnemus grallarius*, is very wide, another point of likeness to *Pluvianus* and, indeed, to other Limicolous birds that will be mentioned presently; indeed, in *E. scolopax* (see text-fig. 25) a separate ileic loop can hardly be defined—this character, in fact, is of the group. In both species of the genus *Edicnemus* that I have examined the jejunum lies more or less in a spiral, which is most marked in *E. grallarius*, though it is only a short spiral of one complete turn even in that species. It is particularly to be noted that this spiral, like that of Passerine birds, is not a permanent spiral, but that it can be pulled out to form an irregular circle without tearing any mesenteries. The genera which have just been dealt with are, in fact, not far removed from the common ground-plan, and the steps of differentiation are quite as is found in the great division of the Picopasseres. A further stage of differentiation is seen in *Recurvirostra avocetta*. Dr. Mitchell has correctly commented upon the spiral formation of the middle part of the gut, the jejunal region of the nomenclature adopted in the present paper.

This bird shows the typical Limicoline characters in (a) the fact that the pancreas extends to the very end of the duodenal loop, (b) in the wide ileic loop, which is about as long as the duodenal, and (c) in the extent of the ileo-duodenal ligament. The spiral is a fairly regular one, and although certainly not longer than, and, I think, hardly as long as, that of the Raven, differs from it in the important fact that it is a permanent spiral. The several coils are, indeed, connected together by mesentery and cannot be separated out without tearing this mesentery. What is a temporary character in the more archaic forms of gut has here become a permanent feature.

The LARI of Dr. Gadow's classification, which I myself prefer to associate more closely with the Limicolous birds, have an intestinal tract which entirely justifies the latter placing. I have examined *Larus ridibundus* and *L. argentatus* among the Gulls. In *L. ridibundus* the pancreas, as in Limicolous birds, extends to the very end of the duodenal loop. The ileic loop is also wide and is attached for the greater part of its length by the ileo-duodenal ligament to rather more than the first half of the duodenal loop. The whole of the jejunum, which is rather long, lies in loose folds like the Mammalian small intestine, with no fixed loops at all. I could not see any trace of a spiral arrangement in this specimen. In *L. argentatus*, however, the jejunum lay in a biggish loose spiral, which was not in any way permanent. There is, in fact, no difference between these two species of *Larus*.

In both, it should be added, there was a distinct supracæcal kink.

I have dissected two examples of *Sterna fluviatilis* which agree absolutely in the characters of their gut. This genus—also like *Larus*—is very definitely like the Limicolous birds. The pancreas, as in those birds, extends back to the end of the duodenal loop. The ileic loop is wide and of about the same length as the duodenal and, finally, the ileo-duodenal ligament is extensive and reaches nearly to the end of the ileic loop in the one case, and for more than halfway along the duodenum in the other. The jejunum lies in a rather short spiral of not more than three circles; the coils of the spiral, however, are not so fixed as in *Recurvirostra*, they can be pulled apart and arranged in about three loops. This state of affairs has been figured by Dr. Mitchell for *Sterna hirundo*, and his figure would fit perfectly the conditions which I found to characterise *Sterna fluviatilis*. There is also a supracæcal kink.

The Auks are associated by some with the Gulls*, but by others they are regarded as forming a distinct assemblage† or are associated with the Grebes and Divers into one group Pygopodes‡. An examination of the intestinal tract of *Fratercula arctica* (text-fig. 26) leads me to reject the former view and to hesitate between one or other of the two latter classificatory schemes. At the same time, it must be added that there is room for divergence of opinion in the interpretation of certain of the loops, as will be seen from the following account, in which I am unable wholly to confirm Dr. Mitchell's account. The duodenal loop is not in any way remarkable and quite unfolded. The pancreas extends nearly, or in one specimen quite, to its end. Thereafter follow two loops, which belong to the middle (jejunal) region of the gut. These are set more or less at right angles to each other; but the direction of the loop is, as I think, of less importance than the fact that there are two of them (and two only), which are roughly equal in size and very distinct.

Moreover, these two loops are interconnected by mesenteries. It is obvious that we have here a close resemblance to the Grebes, *Tachybaptus* and *Podiceps*§, and to those birds only among those whose anatomy in this respect is known. After these follows a large ileic loop, which is different in structure to that of many birds. Mitchell figures it as a simple wide loop. It is, however, long and irregularly looped, and longer than the duodenal loop. It appeared to me that it ended in two prolongations at its blind end, in which case there is an obvious comparison possible with the ileic loop in *Podiceps cristatus*||, which is loosely folded at its blind extremity. The small intestine before the cæca is thrown into another loop, which Dr. Mitchell has duly noted and has

* *E. g.*, Mitchell, *loc. cit.*

† *E. g.*, Beddard, 'The Structure and Classification of Birds': London, 1898.

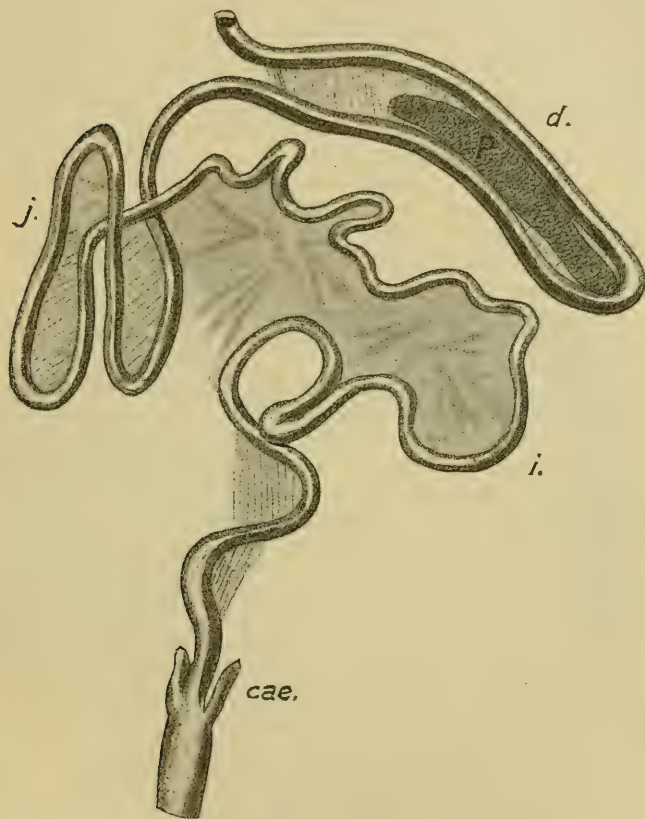
‡ *E. g.*, Vertebrate List Zool. Soc. Lond. 1896.

§ See below, p. 81.

|| See p. 81.

identified with that short loop which he has termed the "supracæcal kink." In a second specimen, all these characters were quite as plain, so that it cannot be held that the first individual was in any way abnormal. Probability, at any rate, indicates this conclusion. A third example, a quite young and immature bird, presented some slight differences which led me at first to suspect

Text-fig. 26.

Intestinal tract of *Fratercula arctica*.

Lettering as before.

a non-identity of species. I am assured, however, that this suspicion is wrong. The only difference concerned the two jejunal loops. Of these the first, *i. e.* that immediately following the duodenum, is much shorter than the second or more distal loop. The latter, instead of being a simple loop equisized with the first loop, is much longer and has a kink, or sudden flexure

to one side, in the middle of its course. It looks, in fact, as if two originally distinct loops were in process of reduction to one. The consideration of this specimen, therefore, renders another comparison possible, namely with the Cranes*, for in these birds the jejunum has three separate loops. In other respects, the third example of *Fratercula arctica* agreed entirely with the other two. Apart from possible resemblances to other groups of birds that have been indicated, the gut of *Fratercula* shows a feature of particular interest in the great length and irregular disposition of its ileic region. This latter is quite unattached to the duodenal loop, except perhaps at the very base; it is long and lies loosely coiled like the Mammalian small intestine. It is, in fact, the longest section of the gut. This bird, in fact, shows an intestine constructed in a way which is exactly opposite to that which is prevalent in the class Aves. When there are tracts of primitive undifferentiated small intestine left it is nearly always the jejunum that is involved, and not the ileic region. In *Fratercula* the jejunum is specialised into fixed loops, while the ileum has remained unspecialised. Indeed, my experience of this structure among birds has only furnished one example at all parallel to the gut of *Fratercula arctica*.

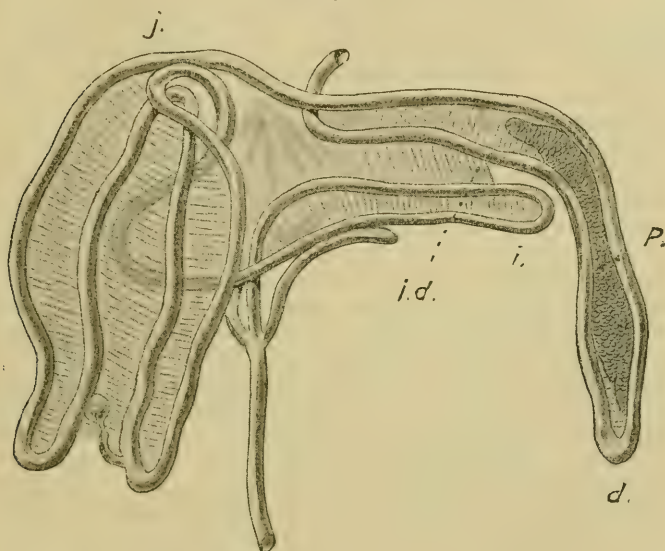
This was an example of the Pheasant, *Euplocamus nycthemerus*. The Gallinaceous birds (see p. 55) are very uniform in the disposition of their intestinal tract, and one out of two examples of this species which I have dissected was perfectly normal in the structure of the gut. A second individual, however, differed. The duodenal loop was immediately followed by a straight, stiffly fixed, descending tube of intestine, which bent back upon itself for a short distance and then passed into a long loosely coiled region, a kink became continuous ultimately with the straight portion of the ileum running to the junction with the caeca. This coiled region of the gut, although lying on the left side of the body, was not in any way attached to the duodenum. There is, therefore, here, it will be seen, a reversal of the conditions found generally among Gallinaceous birds. In this example of *Euplocamus nycthemerus* the stiff descending intestine which immediately follows the duodenum obviously represents in one sense the equally stiff ascending piece of intestine which is in the other example of *E. nycthemerus*, and also in other Gallinaceous birds, parallel to and partly fixed by ligament to the duodenal loop; while in the latter the loose coils which form the major part of the small intestine lie to the right hand. There is, in fact, a precise reversal of the "normal" conditions. There is, as I think, an undoubted resemblance between this "abnormal" example of *Euplocamus nycthemerus* and the normal arrangement of the intestinal tract in *Fratercula arctica*.

PODICPEDES.—I cannot quite explain by means of Dr. Mitchell's figures the intestinal loops of the two Grebes *Tachybaptus*

* Vide p. 82.

*fluviatilis** and *Podiceps cristatus*†, of the former of which species I have examined two examples. The plan of the intestinal tract in the Grebes is very distinct and unlike that of any other birds that I have studied. In *Tachybaptus* the duodenal loop is considerably longer than the ileic (the precise reverse of the conditions obtaining in the Parrots), and the two are attached by a duodeno-ileic ligament which extends about halfway along the ileic loop (see text-fig. 27). I find only two jejunal loops (Mitchell figures four—two long and two short, exactly as in *Ara ararauna*), which are long and closely adherent for the whole of their length. The inner of the two loops, that which is immediately connected with the ileic loop, bore in one specimen a Meckel's diverticulum, as is indeed figured by Mitchell. The cæca extend about halfway along the ileic loop.

Text-fig. 27.

Intestinal tract of *Tachybaptus fluviatilis*.

Lettering as before.

Podiceps cristatus conforms to the general plan seen in the last species, but differs in detail. The ileic loop is peculiar and folded upon itself in a way. If unravelled it would be longer than the duodenal loop, and thus differs from that of *Tachybaptus fluviatilis*, shown in the illustration (text-fig. 27). The extent of the ligament uniting this with the duodenal loop is much as in *Tachybaptus*. In the middle part of the intestine there are only two loops, as in

* Trans. Linn. Soc. tom. cit. p. 186.

† *Ibid.* p. 185, fig. 5.

Tachybaptus; Dr. Mitchell figures five. The two loops are wider than those of *Tachybaptus*, but in the same way connected with each other up to the very end. Like Dr. Mitchell, I could find no Meckel's diverticulum.

Among the RALLI there is apparently but little modification of the intestinal characters from genus to genus. Although I have not examined the actual species which Hunter has described, it is clear that his descriptions are in all probability perfectly correct. Of the "White Fulica [*Porphyrio albus*, Cuv.]" he writes*: "The duodenum passes down as usual, and then up, somewhat higher than at beginning, making a sweep backwards to the loins and commencing jejunum. This passes down on the right side, then up, making a fold upon itself; then a second fold, as also a third, which last is attached to the first fold: all these are parallel to each other. The intestine then passes down, more in the middle of the abdomen, further than the former three folds, along with the duodenum." This fully tallies in the number of loops with Dr. Mitchell's statement and with my own observations; these latter are, I think, worth mentioning in brief, since they further emphasise the uniformity of this group.

In *Hydrornis alleni*, *Rallus abbotti*, *Porphyrio melanonotus*, and *P. madagascariensis* the ileic and duodenal loops are pretty well the same length and are attached by a duodeno-ileic ligament nearly to the end of both loops. In all of these forms there are, as both Hunter and Mitchell assert for species examined by them, three loops only in the jejunal region of the gut. The last of these three loops is the shortest of the three in all of the species which I have just mentioned. In *Porphyrio* (both species) I found a very conspicuous Meckel's diverticulum, which, as Mitchell correctly represents, lies near the bottom of the middle loop. Finally, I may remark that this middle loop, at least in *Porphyrio*, is free from the other two loops (as John Hunter has stated), which are connected by mesentery.

Aramides ypecaha quite agrees with these other types and, as in *Porphyrio*, the pancreas extends to the very end of the duodenal loop. In this form also the first of the three jejunal loops is the widest, and Meckel's diverticulum occurs at about the middle point of the middle one of the three loops.

Among the GRUES I have examined among others *Anthropoides paradisea* and *Balearica*, which do not agree very closely in the nature of their intestinal convolutions with those of *Grus virgo*, as figured by Mitchell. In both these Cranes there are three, and only three, jejunal loops, of which the first (as correctly indicated by Mitchell) is much the widest. The two following are longer and of equal length. On the first of these close to the blind end of the loop there is (in *Balearica*) Meckel's diverticulum. Mitchell figures the ileic loop as trifid. I find that in both the Cranes and in *Grus japonicus* which I have dissected (see text-fig. 18, p. 65) the

* 'Essays and Observations,' p. 317.

ileic loop is a double loop, the two complete rather narrow loops being not quite equisized. *Anthropoides leucauchen* agrees entirely with the other two species, and in all of them the pancreas stops some way in front of the end of the duodenal loop. The existence of three separate loops in the jejunal region is obviously a point of similarity between the Cranes and Rails and of difference between the former and certain other "Alectorides," *e. g.* *Cariama*, Bustard.

STEGANOPODES.—The intestinal tract of a species of *Fregata* has been examined and reported upon by Dr. Mitchell, who, however, was not in a position to state precisely to which species his observations referred. I have examined an example of *Fregata aquila*, and have something to add to the facts enumerated by Dr. Mitchell. He figures and refers to two cæca. I found only one cæcum, which was short and sessile, upon the gut. The duodenal and ileic loops are simple and of about the same length. The pancreas extends only about halfway down the duodenal loop as in Birds of Prey, and the duodeno-ileic ligament is about co-extensive with the pancreas. The duodenum is also connected with the jejunal area by a ligament which I have not found in other birds.

The condition of the jejunal area is interesting when compared with that of other Dysporomorphous birds. It is, comparatively speaking, short, while that of Cormorants and Pelicans is long. This comparative shortness is mentioned by Mitchell, who, however, has not seized upon a difference of some significance, as I think it, which this bird shows from its allies.

In *Phalacrocorax* and *Pelecanus* (the only other genera which I have examined with reference to the matter now under consideration) the jejunum is disposed in a considerable series of closely applied regular fixed loops, as in Ducks, Storks, and some other birds. *Fregata* presents us with a stage anterior to this. There are no definite and regular fixed loops, but the whole jejunum can be disposed in an irregular circle with bulgings here and there. It is not a simple archaic jejunum, as in the Gallinaceous bird; but neither is it the much specialised jejunum of other Dysporomorphæ. It is hardly more advanced in the direction of its immediate allies than is the corresponding part of the intestine in an Eagle or an Owl.

The PSITTACI possess a complicated intestinal tract, which is, as I think, more correctly described by Owen than by Mitchell. For it is quite impossible to represent the various loops into which the intestine is drawn in these birds in the fashion adopted by Mitchell, as will be readily seen by a comparison of the accompanying figure with his illustrations of *Ara ararauna** and *Stringops habroptilus*†. Owen mentions the "packet of folds" which are alternately connected as shown in the text-figure appended, while Mitchell represents a series of loops sometimes bifurcate or trifurcate, though stating that they are "folded

* P. Z. S. 1896, p. 155, fig. 21.

† Trans. Linn. Soc., Zool. (2) viii. p. 244, fig. 61.

upon each other, and twisted and doubled in a complicated fashion." It is easy to state the characteristics of the Psittacine alimentary tract, which in the species and genera *Ara ararauna*, *A. militaris*, *Nestor notabilis* (see text-fig. 28), *Chrysotis inornatus*, *Psephotus hæmatonotus*, *Callocephalon galeatum*, *Platycercus flaveolus*, *Cacatua sulphurea*, is constructed as follows.

The duodenal and ileic loops are single and elongated, as shown in Mitchell's figure. The jejunal loop consists of, proximally, a series of three loops one within the other, of which the ascending limbs of two are connected respectively with the duodenal and ileic loops, and, more distally, of two separate single loops longer than those of the proximal bunch, which are not directly connected with each other but with the loops of the proximal packet. The illustration will explain these interconnections better than a more elaborate description.

Text-fig. 28.

Intestinal tract of *Nestor notabilis*.

Lettering as before.

While there is in the species mentioned the general uniformity of structure which has just been explained, there are differences of small detail. Thus the two species of *Ara* differ, in that the proximal complex of loops in *A. ararauna* consists of only two

short loops, from which it follows that the two long loops inter-communicate directly. These facts, so far, are correctly shown in Dr. Mitchell's figure referred to. *Conurus leucotis* is precisely similar to *Ara ararauna*.

Melopsittacus undulatus is still further reduced. The proximal complex is, as in the last species, reduced to two, but there is only one of the two distal loops left and that is shortened.

On the other hand, *Eclectus pectoralis* is more complex than the forms already considered. Among this group of birds the ligamentum ileo-duodenale is rather short and the pancreas extends to the very end of the duodenal loop, or in some cases nearly so. The ileic loop is often considerably longer than the duodenal. It seemed to me to be particularly long in *Stringaps habroptilus*, where it measured fully 8 inches in length.

Among the PIGEONS I have examined one or two forms not studied by Dr. Mitchell. This group contrasts, for instance, with the Rallidæ in the variety of intestinal patterns which it exhibits. This, it will be noticed, is in accord with variations in the group in other anatomical characters *. I propose, however, to deal with two genera in which the intestine has become shortened in relation to the fruit-eating habit, leaving other forms aside until I have been able to make a more comprehensive study. In one of these, *Ptilopus bellus*, the reduction in length, coupled with great increase in calibre, has not gone so far as in the genus *Carpophaga*, with which I shall deal later. In *Ptilopus bellus* the duodenal loop is quite well marked, though short and rather wide; the pancreas extends to its very end. The jejunal region which follows is also distinct from it and from the ensuing ileic loop. The jejunal region consists of a single loop only, the two limbs of which lie in close apposition, but can be considerably separated without tearing any membranes. This region of the gut is therefore, in consisting of a single loop without further complications, precisely like that of the Bustards and Cariamas. The ileic loop is also well marked and rather wide; it is much longer than the duodenal. The ileo-duodenal ligament is present, but not very extensive. There is also a ligament uniting the jejunal loop to the entering limb of the ileic loop for about halfway down the latter. The plan of the intestinal tract in this bird is therefore a rather primitive one, reminding us of that of *Otis* and *Chunga* and of the Picopasseræ. In fact, the degeneration of the intestine has resulted in the throw-back to a presumably earlier state of affairs.

The genus *Carpophaga* shows a further degeneration of the intestinal tract, which is well known to be very short in this genus of Pigeons †. The shortening is also accompanied by widening.

I have examined *C. aenea* and *C. concinna*. In both of these the duodenal loop has vanished and is represented perhaps by the

* Garrod, "On some Points in the Anatomy of the Columbæ," P. Z. S. 1874, p. 249.

† Cf., e. g., Garrod, "Notes on the Grizzard &c. of *Carpophaga latrans*," P. Z. S. 1878, p. 102.

slightest kink in the alimentary tube. The rest of the tube is disposed in four parallel and transversely arranged lines, which on further examination are seen to form a spiral and which end in a longitudinal section of gut running to the cloaca. I cannot distinguish in this a jejunal from an ileic region. It is interesting to compare with this "degeneration" of the intestinal tract in the fruit-eating Pigeons the corresponding alterations met with in the fruit-eating Passerine *Eluroedus*. In that bird there is a vestige left of the duodenal loop, to the extremity of which the pancreas reaches. Indeed, the rest of the gut has retained, though in a reduced condition, the two recognisable divisions, of which the ileum is represented, as in the primitive Picopasserines, by a straight tract parallel with and connected by the usual membrane to the duodenal loop.

§ *Some General Considerations.*

The new facts which have been described in the foregoing pages give rise to certain reflections upon the affinities which they appear to indicate between different families of birds and upon the course pursued in the evolution of the gut of birds. The facts, so far as they are known, do not appear to me to lead to the establishment of a phylogenetic scheme, even of the evolution of the gut only, so elaborate in the setting forth of details as that which is drawn up by Dr. Mitchell as the result of his own labours in this department of anatomy. Nevertheless, it does seem possible to indicate certain stages in the evolution of the intestine, and here and there are indications, already to some extent considered, of affinities between different Avian families.

§ *The Primitive Form of the Intestine in Birds.*

It is obviously necessary, before considering the features which are the most primitive in the Avian alimentary tract, to get a clear notion of the essential differences which distinguish the alimentary tract of Reptiles from that of Birds; by this means we shall evidently arrive at the essential resemblances. Dr. Mitchell distinguishes the bird's intestine thus:—"It is distinguished from the intestinal tract of reptiles chiefly by the fact that the three divisions—the duodenum, Meckel's tract, and the rectum—are sharply marked off one from the other." These lines are written of *Palamedea*, which that author regards "as representing closely the ancestral type." It appears to me, however, that while *Palamedea* is undoubtedly an ancient type, the definition used by Dr. Mitchell is not a correct one. For, while in, at any rate, the majority of Lizards known to me there is a very marked distinction between the small intestine and the large, the Crocodiles show a further differentiation; for they show a very well-marked duodenal loop as well. The divisions of the alimentary tract therefore do not enable us to distinguish between Birds and

Reptiles. Indeed, in an earlier paper*, Dr. Mitchell has himself sketched in a perfectly correct fashion the alimentary tract from an Alligator, illustrating the facts to which I have just directed attention. From a gut like this it appears to me to be only just possible to distinguish that of *Casuarius*† in its general characteristics, among which I do not include the well-developed cæca. The only difference that I can detect is a closer approximation between the ileic and duodenal regions in *Casuarius*, already, however, marked, though to a less extent, in the Crocodilidæ, which, of course, foreshadows the very close association found in all other birds. This association, caused by the outgrowth of the long middle part of the small intestine from a short region of the primitively straight gut, naturally brings about the commencement of the formation of the fixed ileic loop, so conspicuous a character of the alimentary tract of other birds. It is most interesting to notice that among Crocodiles there is, in some species at least, a quite distinct ileic loop, related perhaps to this same association between the ileic and duodenal regions, which is not, however, as has been already remarked, so close among Birds. It is to be noted that here as elsewhere the closest association of Birds and Reptiles is shown, thoroughly justifying the views of Cope, Huxley, and others. It may be admitted, therefore, that *Casuarius* is, at any rate, one of those birds whose intestinal tract, both arrangement and convolutions, hardly differs from that of Reptiles, and is therefore primitive as compared with that of many other birds. Nor, indeed, is there so far any very great difference from the most primitive form of the gut in Mammals, where, as in *Casuarius* and *Crocodilus*, the entire intestinal tract is borne upon a continuous mesentery.

§ *The Course of the Evolution of the Gut.*

From the simple conditions which obtain in *Casuarius* the more complicated intestinal tract of other birds can be derived; and an almost complete chain of intermediate stages is exhibited, even among the few genera which I have had the opportunity of studying. It is from this point that the characters of the intestinal tract in Birds diverge from those of Mammals, the Reptilian conditions being left behind by both groups of Vertebrates. It may be convenient at this stage to point out the essential differences which distinguish the intestinal tract of Birds from that of Mammals. It has already been pointed out‡ that one difference is to be seen in the fact that among Mammals the permanent loops of the large intestine distinguish that gut from the small intestine, where there are no such permanent loops; whereas in Birds it is the small intestine only which exhibits these permanent loops. These characters, however, though

* P. Z. S. 1896, p. 137, fig. 1.

† I have examined the species *C. rothschildi*, *C. intensus*, and *C. westermanni*.

‡ *E. g.*, Gegenbaur, *Vergl. Anat. d. Wirbelth.*

distinctive in the negative sense are not universal. There are whole orders of Mammals, *e.g.* Carnivora, Marsupials, Primates, Edentata, in which the colon has no permanent loops, while in many birds, *e.g.* Gallinaceous birds, certain Picopasserines, the small intestine has no fixed loops. In addition to this very important difference, there appear to me to be two other distinguishing features in the alimentary systems of the two orders, which are perhaps equally important and are certainly more regularly met with. In all Mammals above those few forms (*e.g.* certain carnivorous Marsupials, certain Edentata*), which have so far retained the Reptilian characters of gut, the whole intestine is rotated upon itself and the rotation is fixed and the change of position of the various sections of the gut retained by the ligamentum cavo-duodenale which moors the end of the duodenal loop to the colon, mesocolon, or median dorsal body-wall on or near the postcaval vein. This ligament correlated with the said rotation is universal among the higher and present in most of the lower Mammals. In Birds, on the contrary, there is no such tract of mesentery fixing the duodenum to the colon. So far, in fact, the bird's intestine has retained the primitive Reptilian condition. The bird's intestine, however, usually has what the mammal's intestine has not, a duodeno-ileic ligament. This doubtless is the physiological equivalent of the duodeno-colic ligament (as Mitchell† has pointed out), in so far as it serves to anchor the perhaps otherwise inconveniently long and coiled small intestine. It may also perhaps be argued from this that a short intestine (*e.g.* many Picopasserines) is shown to be a secondary state of affairs, from the very fact that it is in those birds provided with a duodeno-ileic ligament, which may not be a mechanical necessity. For the existence of the ligament in question may be due to mechanical needs in an ancestor with a long small intestine. In any case, the morphological fact is to be noted and it constitutes a real difference between the Mammalian and Avian gut.

In very nearly all birds whose intestinal tract is at or above the level of that of the Cassowary, the end of the small intestine‡ is attached by a mesentery of varying degree of development to the duodenum. This, without any further specialisation, is the first stage in the evolution of the gut from its simple archaic form. This stage characterises the hypothetical Gallinaceous birds in which it is universally present and quite similar in all.

This simple stage, which we may term *Stage A*, is also found in other groups, but it does not occur in all the members of any other group as it does in the case of the Gallinaceous birds. Among the Struthious birds, for example, we have it in the Cassowaries, Ostrich, and *Apteryx*§, whose intestinal tracts are

* For a general survey, see Klaatsch, *Morph. Jahrb.* xviii. 1892, and myself in *P. Z. S.* 1908, p. 568 &c.

† *Trans. Z. S.* xvii. p. 524.

‡ The chief exception known to me is furnished by *Fratercula arctica*, the remarkable characters of the intestine of which bird I have already commented upon (*supra*, p. 78).

§ The condition of *Rhea* requires perhaps further study.

precisely similar so far to that of the Gallinaceous birds. We have in certain Picopasserres (e. g., *Melanerpes*) the same state of affairs, coupled in this case with a considerable shortening of the gut. Among the Limicolæ the genus *Pluvianus* is also in this stage.

The next stage, which may be called *Stage B*, is like the last, save for the fact that the ileic loop is definitely formed. The jejunal region remains unspecialised. To this stage, we refer the gut in the majority of Picopasserres, including the Cuckoos and Plantain-eaters. The "Alectorides" (in the sense in which I venture to use that term in the present communication) seem, but perhaps only seem, to belong to this stage. Among the Limicolous birds *Sarcophorus* and Gulls appear to belong here. Perhaps we should also place in this assemblage the Dysporomorph *Fregata*.

Stage C is a slight advance upon the foregoing. It is exemplified in certain Owls and Hawks, where the ileic loop is fully differentiated off and attached in the usual way to the duodenum, and where the jejunum is largely laxly coiled without any definite loops, save a single loop, and that not a very well-marked one, which occurs at the commencement of the jejunum. I have not noticed this kind of intestine in any other group, except the Nocturnal and Diurnal Birds of Prey.

Stage D might possibly be further divided up, but for the present I do not see a clear way through the great variations which the intestine of the more complicated forms shows. In all of them the jejunum has become differentiated into fixed loops, which vary in number, in relative length, and in their relations one to the other. The majority of the larger birds belong to this stage, as, for instance, the Cranes, Rails, Ducks, and Storks.

§ *The Mutual Affinities of Avian Families judged by the Intestinal Convolution.*

The known facts do not, as I think, permit of any complete scheme of classification of Birds by means of the variations in the coils of the intestinal tract. Here and there, however, there would seem to be such indications, which are tolerably well marked. More frequently, however, either a general plan runs through a series of two or three groups, which makes any definite placing of these groups in reference to each other difficult, or a complete isolation is shown. The most salient instance of the latter conclusion is undoubtedly the group of Parrots, whose intestinal coils are constructed upon a plan which is apparently universal in that group, but totally unlike anything which is to be found in any other group. The affinities of the Psittaci have been very variously interpreted*, but it is clear that the gut does not enable one to decide upon any of these diverse views. I cannot at all agree with Dr. Mitchell in saying

* Many or most of these opinions are mentioned by Fürbringer in his monumental work, 'Untersuchungen ueber Morph. u. Syst. der Vögel,' Amsterdam, 1888.

that "the relation to the common type is, however, easily made out" *.

In the same way, the Ralli are a quite circumscribed group judged by their intestinal coils, which bear only a general resemblance to other groups and, indeed, to no group in particular. Their characters are constant throughout the group, so far as known facts enable us to make a statement. The most that can be said is, perhaps, that they are nearer to the Grebes than the latter are to any other subdivision of the Bird tribe. On the other hand, it seems to me to be quite clear that if judged by their intestinal coils the newer ideas with respect to the New World Vultures and other Accipitres † must be abandoned, as Dr. Mitchell has correctly pointed out; it is necessary to revert to the older view which regarded the Condors as merely Vultures. In the same way, although in this Dr. Mitchell does not agree with me, the older opinion as to the Owls, that which placed them close to the Accipitres and not in the neighbourhood of various Picarian genera, is most certainly justified by the close similarities in the mode of arrangement of the intestinal loops. At the same time, it is also easy to distinguish these two groups by the small but constant characters afforded by the ileo-duodenal ligament.

And, again, it is by no means possible to distinguish by characters that carry any conviction the intestinal tract of a Grebe or Tern from that of the Owls on the one hand or large Passerine birds on the other; while the Gulls and Terns on their side offer resemblances to what I venture to term "the other" Limicoline birds. Negative features are perhaps more salient in making a brief survey like the present. Thus it is clear that the Tinamous are quite unlike the Gallinaceous birds and that the genus *Turnix* is equally to be removed from that assemblage. The Bustards and *Cariamā*, moreover, show no particular likeness to the Cranes, though the first two seem to be closely allied to each other, as I have already pointed out. It is noteworthy that all the four types ‡ of Struthious birds differ from each other as much as would seem to be possible in view of the undoubtedly primitive characters of the gut in all of them, with the possible exception of *Rhea*.

§ *The Relationship between the Gut and the Nature of the Food.*

When we contrast the intestine of a Penguin with its enormous series of closely adpressed straight loops and the intestine of a Bustard with only three short intestinal loops, there would appear to be a very marked difference between a fish-eater and an omnivorous bird, and thus a close relationship between the form and length of the gut and the nature of the food eaten by its

* P. Z. S. 1896, p. 155.

† These opinions are so well known that I need not quote what would have to be a long list of books and memoirs.

‡ *Casuarinus* and *Dromæus* belong, of course, to the same type.

possessor. There is not, however, in all cases a relationship which is plainly to be recognised between differences in diet and differences in the intestinal part of the alimentary tract, and on the other hand a totally different diet sometimes coincides with a close similarity in the intestinal convolutions. Phylogenetic relationship appears to me to have much more to do with these similarities and differences in the gut. Furthermore, the way in which the intestinal tract is modified in accordance with the diet, when it does appear to be so modified, seems to have pursued a different path in different groups in some cases. Of fish-eating birds, for instance, the general idea is that the gut is long, and that undoubtedly is the case with the Penguin and the Cormorant-Pelican group. But then in these groups no representatives are known which are not fish-eaters. Directly we come to the consideration of groups of birds which contain fish-eating genera and genera whose food is not fish, we are sometimes met by a totally different state of affairs.

According to the statistics collected by Mr. Newstead*, the Terns (of three species) are exclusively fish-eaters. Yet their gut is not markedly and indeed hardly at all different from that of the Avocet, which devours aquatic insects, and some other Limicolæ which select a similar diet. The Kingfisher (*Alcedo ispida*), which is, according to the same authority, practically entirely a fish-eater, has a gut which is very like that of the omnivorous Corvines, and has, moreover, a much shorter spiral jejunum than in the differently feeding *Halcyon sancta*. The Toucans† are mainly fruit-eaters, though, like so many birds, they will vary this diet with animal food. And yet their intestinal tract differs very little from that of *Podargus*, which is presumably not at all a fruit-eater, but subsists entirely upon insects and other animals. Again, the Touracous‡ are fruit-eating birds; but their gut is like that of a vast series of Pico-passerine birds which feed upon all kinds of food.

In asserting that the gut is short in all purely frugivorous and insectivorous birds, Dr. Gadow practically admits how little stress can be laid upon the relationship between length of gut and the nature of the food. For the nature of the diet in each case is as different as possible. Nor can any general principles be stated as to the complication of the gut in families of birds which live differently. Thus the plan of the gut in *Apteryx* is practically identical with that of the Gallinaceous birds, and the character of the food differs. On the other hand, the pattern of the gut in Accipitrine birds is not dissimilar to that of Owls, and here we have a general similarity in diet. It is, in fact, not possible to lay down general rules which have not copious exceptions. Many of these exceptions can be gathered from the foregoing pages.

* Supplement to the Journal of the Board of Agriculture, vol. xv. No. 9 (1908).

† Newton, 'A Dictionary of Birds' (London, 1893), *sub voce* "Toucan."

‡ *Id. ibid.*, "Touracou."

§ *Id. ibid.*, "Digestive System."

§ *Summary of Facts relating to the Intestinal
Coils of Birds.*

We are in a position, I think, to lay down with confidence the following general statements with regard to the intestinal tract of the Class Aves. These statements are deduced from the memoirs of others who have written upon this subject, as well as from the facts ascertained by myself, and embody in a brief form what is known upon the subject dealt with in the present communication:—

(1) There are no essential differences between the intestinal tract in Birds and in Crocodilia. The most complicated alimentary tract in Birds can be derived through a series of stages from the simple Crocodilian form.

(2) The intestinal tract of Birds differs from that of Mammals in that there is never in the former, as there is generally in the latter, a rotation of the gut coupled with an attachment of the duodenum to the colon or mesocolon by a duodenal caval ligament. On the other hand, there is nearly always in Birds an ileo-duodenal ligament which serves to hold together the gut and which is wanting in Mammals. Furthermore, in Mammals the colon may be specialised into fixed loops, while in Birds such fixed loops are found only in the small intestine.

(3) The small intestine of Birds can, with rare exceptions, be distinguished into duodenal, jejunal, and ileic regions.

(4) The duodenal region consists of a long well-defined loop (only absent in certain fruit-eating Pigeons), which is usually straight, but sometimes (e. g. *Milvus*) shows indications of—or a pronounced—spiral arrangement, as it does also in certain Crocodilia. It is wider or narrower in different groups, and the enclosed pancreas extends a greater or a less way towards the extremity of the loop in different birds.

(5) The jejunal region is sometimes (e. g. Gallinaceous birds) marked off from the duodenal by a sudden diminution in calibre. It is usually the longest section of the gut; but is sometimes as short or even shorter than either the duodenal or ileic region or both. It may be a tract of intestine without any fixed loops (as in the Gallinaceous birds, various Passerines, &c.), but if of considerable length is usually specialised into a series of two or more fixed narrow loops, which may be interconnected by secondary mesenteries in different ways, distinctive of different groups of birds. An intermediate condition is seen (e. g. among Accipitres and in *Fregata*), where the jejunum is not arranged in lax and alterable coils as in the Gallinaceous birds, but is stiffened here and there into wide loops, which are not so sharply marked off as in the more specialised birds and are not interconnected by secondary mesenteries.

(6) The ileic region is not always quite distinct from the jejunal, and degrees of distinctness occur. In less specialised intestines there is no definite loop, but the end of the ileum is

attached for a variable distance by a secondary mesentery to the duodenal loop. In more specialised intestines the ileic region forms a distinct loop which is narrower or wider, and which is equal to, longer, or shorter than the duodenal loop, to which it is attached for a greater or less length by the ileo-duodenal ligament already mentioned. Not infrequently the ileic region consists of two loops, of which one is often small and lies just above the cæca.

(7) The plan of the gut is constant (except for very slight variations) in all the members of certain groups. This is the case with the Psittaci, Galli, Raptores, Striges. In the case of other groups, there are considerable divergences of structure within the group: this is the case with the Picopasseres, Limicolæ, Grues, Struthiones (if, that is to say, the two latter groups can be regarded as natural groups, which is open to doubt on other grounds).

(8) A comparison of the intestine of Birds with that of Reptilia (especially Crocodilia) allows of the recognition of more and of less primitive types of intestine. The most primitive type is found in the Cassowaries, *Struthio*, *Apteryx*, and all the Gallinaceous birds; and is also seen among the Picopasseres (Woodpeckers) and Limicolæ (*Pluvianus*). Most Picopasseres and the Birds of Prey (nocturnal as well as diurnal) show a rather more specialised form of intestine. In the remaining groups of Birds the intestine is more specialised still and in several different directions.

(9) Certain classificatory results seem to follow from a comparison of the differences exhibited by the intestinal tract. Thus, the resemblance of both Cuculi and Musophagi to the Picopasseres, and the likeness between all the Accipitres (New World and Old World, nocturnal and diurnal) are remarkable. The close likeness between the Bustards and the Cariamidæ is to be commented upon. The Passerine character of the gut of *Turnix* and the possible likeness between *Crypturus* and *Rheo* seem also to be shown.

7. On the Specimens of Spotted Hyænas in the British Museum (Natural History). By Prof. ANGEL CABRERA, C.M.Z.S.

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Every zoologist working on the Spotted Hyænas with suitable material from different localities feels the convenience of recognising several local forms. As early as in 1812, two of them were admitted by Cuvier, and in modern times no less than nine other "species" have been described. It is not easy to say with which form Erxleben's *Hyæna crocuta*, afterwards the type of the genus, or subgenus, *Crocuta*, must be identified, as the species was

based on the "Spotted Hyæna" of Pennant*, and this author gave no definite locality, saying only that the animal is found in "Guinea, Æthiopia, and the Cape." That indication practically embraces all the African countries known in Pennant's time, excepting only Barbary and Egypt. As to the original description, made from a specimen shown in London some years before, it runs thus:—

"Short black mane: hair on the body short and smooth: ears short and a little pointed; their outside black, inside cinereous: face, and upper part of the head, black: body and limbs reddish brown, marked with distinct round black spots; the hind legs with transverse black bars; tail short, black, and full of hair."

Now, I have never seen, nor found described, a Spotted Hyæna with black mane. Young specimens commonly have dark hairs in it, producing a general blackish tinge, but it seems clear that Pennant's specimen was not young, as in the description it is afterwards stated that it was bigger than the striped species, and the author says about the latter in a previous page that it is larger than a big dog. It is therefore necessary to suppose either that Pennant spoke from memory and forgot some details of the coloration, or that the actual specimen represented a form quite unknown to modern naturalists. The latter view being a very unlikely one, I prefer to think that the description was written from memory only, under the impression of a reddish-brown animal spotted with black, and perhaps a not quite developed specimen with a little of the juvenile dark hair in the mane.

This determination being adopted, it seems to me very probable that the specimen alluded to came from Senegambia, although this locality is not mentioned among those given by Pennant as inhabited by Spotted Hyænas. Senegambia and the Cape were, during the eighteenth century, the two countries that chiefly and almost exclusively furnished the European menageries with African animals. But in the Cape Hyæna the ground-colour is a dirty yellowish which nobody would call reddish brown, whereas this rather indefinite designation may be correctly applied to the peculiar colour, intermediate between dark cinnamon and raw umber, of the Senegambian Hyæna. The fact that Pennant did not include Senegambia in the habitat of the species is of little, if any, importance, as he compiled the geographical distribution from the works of Bosman, Kolbe, &c., and was evidently unaware of the provenance of the specimen he saw in London. In his 'Game Animals of Africa,' Mr. Lydekker says that the typical *Hyæna crocuta* is the form found from Southern Egypt, across Central Africa, to Senegal in the west and the Transvaal in the south. I cannot agree entirely with such a conclusion. As will be seen below, Spotted Hyænas from the Nile Basin and East Central Africa are very different in colour from the animal described by Pennant and Erxleben, and therefore

* 'History of Quadrupeds,' i. (1781) p. 252.

these countries at least must be discarded. The supposed distribution being restricted in this manner to Central Africa and Senegambia, it becomes clear that, as Central Africa was totally unknown to Europeans in Pennant's time, the only conclusion at which we can arrive from Lydekker's statement is that which I have adopted. *Crocota crocuta* may therefore be selected as the name for the Senegambian Spotted Hyæna, at least until a stronger argument can prove that this view is not the right one.

As I have said above, Cuvier, in his 'Ossements Fossiles,' distinguished two different forms of Spotted Hyænas, a grey one and a reddish one. In the second edition of the same work, he states that his reddish Hyæna is frequently found about the Cape, but the source of this knowledge is not given. The first exact description of the Cape Hyæna is by Desmarest*, who named it *Hyæna capensis*. As to *H. rufa*, of the same author, based on Cuvier's reddish Hyæna, its exact locality being unknown, it is best to consider it as a synonym of true *crocota*. Boitard† gives the three names to one and the same animal, and describes a yellowish Hyæna from the Cape as *H. cuvieri*, this name becoming thus a synonym of Desmarest's *capensis*.

Since the publication of all these old names, no other splitting of the group has been attempted till 1900, when Matschie‡ described five so-called new species: *Crocota wissmanni*, from German West Africa; *C. garipeensis*, from the Orange River; *C. germinans*, from German East Africa; and *C. thierryi* and *C. togoensis*, from Togo. In a subsequent paper§, the same zoologist named the form from Kamerun *C. noltei*. Satunin|| has given the name *leontiewi* to the Abyssinian Spotted Hyæna, and Lönnberg¶ has described two other forms from East Africa, *C. kibonotensis*, from Kibonoto plains, and *C. panganensis*, from the Pangani River.

It is impossible to decide now, without the comparative study of large series of specimens, and especially of skulls, whether all these forms are true different species, or whether they are local races of one or of several species. From the material in the British Museum, which I have been able to examine through the kindness of Mr. Oldfield Thomas, F.R.S., it appears that two different types of skulls may be distinguished:—a broad one, in which the width of the palate across the upper carnassials is practically equal to or a little greater than the length of the lower tooth-series exclusive of incisors; and a narrow one, in which the width of the palate is equal to or a little less than the length of the upper tooth-series. This latter always being 4–15 mm. shorter than the lower tooth-row, it is clear that the difference between the two types can be

* 'Mammalogie,' i. (1820) p. 216.

† Le Jardin des Plantes, 1845, p. 232.

‡ SB. Gesellsch. Nat. Fr. Berl. 1900, pp. 18–58.

§ L. c. 1900, p. 211.

|| 'Zoologischer Anzeiger,' xxix. (1905) p. 556.

¶ Sjöstedt, Kilimanj. Meru Exped. 1908, pp. 16–18, pls. 5 & 7.

detected at first glance. Moreover, the ratio between the zygomatic breadth and the condylo-basal length is 65 to 72.5:100 in narrow skulls, and 70 to 75:100 in broad skulls. Of course, I refer solely to adult specimens; in young skulls the proportions are very changeable, according to the age.

Three only among the eleven forms described up till now seem to be represented in the British Museum collection, as follow:—

CROCUTA CAPENSIS Desm.

Two adult specimens, one from the Cape (B.M. no. 46.8.3.3, *Turner*), and another from the Pongola River, Zululand (B.M. no. 2.2.8.1, *D. Bruce*), and a young one from the Cape (B.M. no. 37.9.26.90, *Turner*). Ground-colour dirty cream-buff; spots small, round, numerous, and of a pale hair-brown; mane dirty ochre-yellow; snout and feet dark-coloured, between sepia and hair-brown. Skull of the broad type.

Skull-measurements of no. 46.8.3.3.—Condylo-basal length, 236 mm.; zygomatic breadth, 176; interorbital breadth, 57; postorbital constriction, 42; rostral breadth on canines, 64; width of palate across the carnassials, 114; mandible, from condyle, 180; upper tooth-series*, 100; lower tooth-series, 111; upper carnassial, 35 × 22; lower carnassial, 30 × 12.

A specimen from the Cape in the Madrid Museum of Natural Science is entirely like the British Museum specimens. The figure given by F. Cuvier in his 'Histoire Naturelle des Mammifères,' after a living animal obtained in the same locality by Capt. Baudin, is not good, the difference in height between the fore and the hind quarters being too exaggerated.

CROCUTA WISSMANNI Matsch.

An old specimen from Linyanti (B.M. no. 0.10.3.1, *P. C. Reid*). Ground-colour ochraceous; under surface, from the throat, pale cream-colour. The spots are very dark brown and show a tendency to form longitudinal rows on the flanks. On the limbs they are darker, almost black, and reach a lower level than usual in the group. Mane ochraceous. Snout dark brown. Feet buff-yellow. Skull of the narrow type.

Skull-measurements.—Condylo-basal length, 256 mm.; zygomatic breadth, 185; interorbital breadth, 64; postorbital constriction, 53; rostral breadth on canines, 66; width of palate across carnassials, 112; mandible, from condyle, 190; upper tooth-series, 113; lower tooth-series, 117; upper carnassial, 35 × 20; lower carnassial, 32 × 11.

It is not without hesitation that I call this specimen *wissmanni*, as it lacks the black feet which Matschie says are characteristic of the German West Africa Hyæna, and which are to be seen in

* In describing Carnivora, I always measure the tooth-rows from the front of the canine to the back part of the hindmost cheek-tooth.

Schreber's plate xevi. (Säugth.), with which *wissmanni* is identified. But the ochraceous ground-colour, the paleness of the under parts, and, moreover, the relative proximity of Linyanti to Epukiro, the type-locality of *wissmanni*, prevent me from giving it a new name, at least until some other specimens are available. By the way, the material on which *Crocota wissmanni* was based is far from good. The type is a skin without skull, and Prof. Matschie is not sure that the skull from Windhoek, described in his paper, really belongs to the same form.

CROCUTA LEONTIEWI Satunin.

A skull, without skin, from Abyssinia (B.M. no. 69.2.2.13, *Jesse*). Its dimensions answer rather well to those given by Satunin for his specimen 5784. It belongs to the narrow type and is broken behind, it being, therefore, impossible to measure its condylo-basal length.

Skull-measurements.—Zygomatic breadth, 153 mm.; interorbital breadth, 55·5; postorbital constriction, 41; rostral breadth on canines, 58; width of palate across the carnassials, 99; mandible, from condyle, 172; upper tooth-series, 98; lower tooth-series, 103; upper carnassial, 36 × 19; lower carnassial, 26 × 10.

Another skull, without skin, from the White Nile (B.M. no. 2.8.5.4, *Maj. Dunn*), seems to belong to the same species; whereas another from Bar-el-Zaraf (B.M. no. 0.8.6.2, *Stanley Flower*) evidently represents a different form, perhaps the Sudanese Hyæna, which I do not dare to name without knowing the colours. It is of the broad type, and undoubtedly came from a very big animal.

There are in the British Museum, besides the specimens just mentioned, some others representing three different and apparently new forms. In describing them, it is only provisionally that I use binomial names.

CROCUTA RUFOPICTA, sp. n.

Diagnosis.—A very pale reddish form with red spots, quite different from the grey Hyænas of Abyssinia and Uganda.

Colour.—Ground-colour pale ochraceous buff, verging to tawny ochraceous on the back and the mane, and fading to pale buff on the under parts. Spots small, very scattered, and ochraceous rufous in colour. Feet ochraceous. Tip of the tail blackish, as usual in Spotted Hyænas.

Skull.—Palate narrow, its greatest breadth being rather less than the length of the upper tooth-series. Bullæ elongate; paroccipital processes considerably drawn backwards, their hind outlines appearing, when the skull is resting on its basis, as oblique lines.

Skull-measurements (of type).—Condylo-basal length, 240 mm.; zygomatic breadth, 159; interorbital breadth, 53·5; postorbital constriction, 40; rostral breadth, 59; width of palate across the carnassials, 97; mandible, from condyle, 178; upper tooth-series,

103; lower tooth-series, 106.5; upper carnassial, 36×20 ; lower carnassial, 28×11 .

Hab. Odueina, Boran Country.

Type. Old female. B.M. no. 9.6.1.14. Collected by Mr. Drake-Brockman.

Remarks.—The type-skin lacks the head and fore part of the neck, but it is so different from all the other Spotted Hyænas that, although the only specimen and an incomplete one, it deserves to be considered a new form. *C. kibonotensis*, pale reddish in colour like *rufopicta*, has the spots dark brown, not red, and its skull, an excellent photograph of which has been published by Lönnberg, is also different from that of the present species or race.

CROCUTA THOMASI, sp. n.

Diagnosis.—A pale grey, black-spotted Hyæna, with the skull of the narrow type.

Colour.—General colour pale grey, strongly suffused with buff on the fore quarters, and marked with large black spots, very irregular in form, some of them being elongate and even somewhat linear. Mane dirty ochre-yellow, fading to cream-buff on the sides of the neck, where there are two irregular rows of faint burnt-umber spots. Feet and legs to near the elbow and the knee dark clove-brown, almost black. Tail pale grey, blotched with small blackish spots, and with the distal half black.

Skull.—Palate narrow, but not so much as in *C. rufopicta*, its largest breadth being practically equal to the length of the upper tooth-row, and even considerably exceeding it in young specimens, in which the carnassial is not yet quite developed. Hinder outline of paroccipital processes forming a vertical line.

Skull-measurements (of type).—Condyle-basal length, 245 mm.; zygomatic breadth, 165; interorbital breadth, 54; postorbital constriction, 41; rostral breadth on canines, 58; width of palate across the carnassials, 101; mandible, from condyle, 175; upper tooth-series, 100; lower tooth-series, 107; upper carnassial, 35×18 ; lower carnassial, 26×10.5 .

Hab. Ankole, Uganda.

Type. Adult male, B.M. no. 1.8.9.27. Collected by Sir Harry Johnston.

Remarks.—I have seen two other specimens, from Ankole also, one obtained by Sir Harry Johnston (B.M. no. 1.8.9.28) and the other, a young female, collected by Mr. Delmé Radcliffe (B.M. no. 5.4.3.4). All three are readily distinguishable from the other grey Hyænas of East Africa. The Abyssinian *C. leontiewi* is not pale grey in colour, but "bräunlichgrau, auf der Mitte des Rückens rostbräunlich," and has a smaller skull (zygomatic breadth about 155 mm., against about 165 in *C. thomasi*). In *C. panganensis*, from the Coast Region, the colour is darker, brownish ash, verging to rusty brown in the mane, and the skull is considerably broader behind the postorbital processes. The

West-African *C. togoensis* appears to be the only species similar in colour to the Uganda Hyæna, but according to plate 104 of Dr. Heck's 'Lebende Bilder aus dem Reiche der Tiere,' in which the type of the species is figured, in the Togo Hyæna the large spots are more regular in form, and there are among them some very small spots which are not present in *thomasi*. The skull of *togoensis* is, moreover, of the broad, not of the narrow, type. The original specimen is a young one, and therefore useless for comparison, but an old topotypical specimen in the Berlin Museum, Prof. Matschie kindly informs me, presents the following dimensions: width of palate across the carnassials, 107·1 mm.; upper tooth-series, 99·8; lower tooth-series, 109·3. Of course, it was not to be expected that a so plastic group would be represented by the same form in two countries so widely separated.

I have much pleasure in naming the Uganda Hyæna in honour of Mr. Thomas, as a remembrance of the kindness shown me while examining the invaluable collections under his charge.

UROCUTA NYASÆ, sp. n.

Diagnosis.—A pale yellowish Hyæna, with large dark spots and pale brown feet.

Colour.—General colour dirty buff; mane pale ochraceous; belly dark brown. The spots are dark Vandyke-brown, large and very scattered on the body, smaller and more close-set on the limbs. On the sides of the neck there are some faint traces of brownish-red spots. The muzzle is of a pale, dirty wood-brown, and the feet are of this same colour, somewhat lighter.

Skull.—Palate long and narrow, its greatest breadth practically equal to the length of the upper tooth-row. Zygomatic arches comparatively close to the skull.

Skull-measurements (of adult female, paratype).—Condyle-basal length, 260 mm.; zygomatic breadth, 179; interorbital breadth, 61; postorbital constriction, 48; rostral breadth on canines, 69; width of palate across the carnassials, 110; mandible, from condyle, 190; upper tooth-series, 111; lower tooth-series, 119; upper carnassial, 38×20 ; lower carnassial, 32×12 .

Hab. Mount Milanji, South Nyasaland.

Type. Immature skin and skull. B.M. no. 92.8.1.5. Collected by Alexander Whyte and presented by Sir Harry Johnston.

Remarks.—There are in the British Museum, besides the type, an old female skull (92.8.1.4), measured above, and a stuffed specimen exhibited in the public galleries, both received from Sir Harry Johnston. The species, which very probably is the same as found in Portuguese East Africa, is readily distinguishable from *C. germinans*, its geographically nearest ally, this latter being a much darker animal, wood-brown with the mane clay-colour.

EXHIBITIONS AND NOTICES.

December 13, 1910.

G. A. BOULENGER, Esq., F.R.S., Vice-President,
in the Chair.

THE SECRETARY read the following report on the additions made to the Society's Menagerie during the month of November, 1910:—

The number of registered additions to the Society's Menagerie during the month of November last was 181. Of these 72 were acquired by presentation, 31 by purchase, 33 were received on deposit, 35 in exchange, and 10 were born in the Gardens.

The number of departures during the same period, by deaths and removals, was 209.

Amongst the additions special attention may be directed to:—

1 American Bison (*Bison americanus*), born in the Menagerie on Nov. 1st.

5 Canadian Wapiti (*Cervus canadensis*), 1 ♂, 4 ♀, from Canada, purchased on Nov. 8th.

1 Tasmanian Wolf (*Thylacinus cynocephalus*), ♂, and 2 Tasmanian Devils (*Sarcophilus satanicus*), from Tasmania, purchased on Nov. 21st.

Dr. H. HAMMOND SMITH, M.R.C.S., F.Z.S., exhibited a mounted specimen of the Red Grouse (*Lagopus scoticus*) which displayed a curious variety of the ordinary plumage, and made the following remarks:—

"This Grouse was sent to me by Mr. Wynyard Dixon, of Sheffield, from the Gilkerscleugh Moors, Abington, Lanarkshire, on October 4th this year. The bird is a cock. The colouring is not common, and the specimen is not quite like the so-called pepper-and-salt variety, of which I saw a good example at Mr. Boyals, where this bird was set up. In the bird now exhibited, while the wings show grey colour, the feathers under the chin are more like the colour of the feathers of a young cock pheasant, and there is just an appearance of a light ring round one side of the neck; there are also a few bronze-coloured feathers on the flanks. Of this moor Mr. Dixon says in one of his letters: 'I was much surprised the first time I came to this district to find pheasants on the moors considerable distances from coverts or farms—in fact, the pheasants do not appear to come into the spinneys till November'; he further states that he has seen them two miles from any covert. But all who have shot on moors adjoining pheasant preserves are aware that pheasants will stray for very long distances over the moors from the coverts, especially if there are bilberries to be found. It has been suggested that this bird may be a hybrid between the pheasant and the grouse; I can find no previous record of such

a hybrid. Grouse vary considerably in their colouring from very dark to cream-colour. I do not personally contend that this bird is a hybrid; in my opinion it is a Grouse, and I show it this evening as a curious variety of the colouring of the ordinary Red Grouse."

Other zoologists present confirmed Dr. Hammond Smith's opinion that the bird was not a hybrid.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited some skins of the Australian Yellow-rumped Finch (*Munia flavi-prymna*). These birds had been kept alive in an outdoor aviary in England, and had developed certain markings tending towards those of another closely allied species, *Munia castaneithorax*. The exhibitor attributed this to the fact that the former species was a desert form of the latter, and when placed in a humid environment tended to revert to the plumage of the latter. He referred to a paper he had published on this subject in the 'Avicultural Magazine,' 1907, p. 195.

Dr. W. E. HOYLE, M.A., F.Z.S., English Member of the International Commission on Zoological Nomenclature, explained the Report presented to the Graz Meeting of the International Zoological Congress, and referred in particular to the proposals made for the protection of well known zoological names.

A discussion followed on the portion relating to the formation of an Official List of most frequently used Zoological Names. The feeling of the Meeting was very strongly in favour of the International Congress giving its authority to the forming of a List of Zoological Names, the significance of which should not be altered by application of the rules of the International Code. It was unanimously agreed to accept the action of the Congress if it would adopt this course.

PAPERS.

8. On the Segmentation of the Occipital Region of the Head in the Batrachia Urodela. By EDWIN S. GOODRICH, M.A., F.R.S., F.Z.S., Fellow of Merton College, Oxford.

[Received November 29, 1910: Read December 13, 1910.]

(Text-figures 29-51.)

Introduction.

It is now well known that in the Craniata Gnathostomata the region of the head lying behind the auditory capsule is a compound structure, formed of a number of segments originally

like those of the trunk. A process of cephalisation leads to the fusion and partial suppression of a number of skeletal segments, or scleromeres, which combine into a compact occipital region continuous with the remainder of the skull in front. Through its wall issue segmental nerves. At the same time, there is a tendency for the corresponding muscular segments to become reduced. The history of this subject has been so often told that it need not be repeated here (Sewertzoff 9, Gaupp 3, and myself 6).

The occipital region in the Amniota has been found to include behind the vagus nerve four scleromeres enclosing three roots of the hypoglossus nerve. There are therefore probably at least five segments altogether between the auditory capsule and the atlas—the first corresponding to the glossopharyngeal, the next to the vagus, and the last three to the hypoglossal. Possibly there are a few more.

In the Pisces the posterior limit of the head is both less definite and more variable in position; but the postauditory region probably always includes at least seven segments. The Selachians have been most thoroughly studied, and in them there are about eight segments behind the auditory capsule (metaotic segments). The first corresponds to the glossopharyngeal nerve and the fourth mesoblastic somite (three of these being proötic); the next four segments belong to the vagus, and the last three to the hypoglossus, much as in Amniotes. But in the Selachian the anterior sclerotomes and myotomes are more distinct. The first metaotic somite produces no myotome, and therefore preserves no ventral nerve-root. The remaining occipital somites contribute to the hypoglossal musculature, and their corresponding ventral roots are the spino-occipitals of Fürbinger ($s-z$). But the muscles of these segments tend to disappear in ontogeny from before backwards. In adult Selachians some two or three hypoglossal roots are usually found piercing the occipital region of the skull. An examination of the early stages, however, reveals the complete series of somites, nerves, and skeletal segments, which make up the postauditory region of the head.

Very different is the state of things in the Batrachia (Amphibia). Here the skull appears to end immediately behind the vagus foramen; and nerves contributing to the hypoglossal issue from the vertebral column behind the occipital condyles.

The first, second, and third spinal nerves may form the complex hypoglossal; the second being the main, and often the only, hypoglossal nerve in the adult.

These facts immediately suggest several questions:—Does the occipital region of the Amphibian really include fewer segments than that of the other Gnathostomes, or have certain segments been telescoped and practically crushed out? Are the hypoglossal segments of the Gnathostomes really represented by the first three trunk-segments of the Amphibian, or have these simply assumed the function originally fulfilled by others farther forward?

Further, if the Amphibian head includes fewer segments, it may be asked whether this condition is primary, or due to the return of segments to the trunk which formerly held a place in the head.

It is essential before attempting to answer these questions to determine how many head-segments can actually be traced in ontogeny. Other observers have attacked the problem, but their results are not in agreement. With a view to settling this point I undertook the study of the development of the head-region in the Axolotl (*Amblystoma tigrinum*).

My method has been to reconstruct series of sections on paper. For this purpose it is important to have a very complete set of stages cut in various directions. I have to thank Dr. J. W. Jenkinson for the loan of a large number of excellent series of sections filling up the gaps in my own preparations. An appropriate number of stages has been selected for representation in the figures given in the text; but it will be understood that intermediate stages have been examined. Of these figures, nos. 33-38, 40-43, and 45-49 were drawn from Mr. Jenkinson's series.

Description.

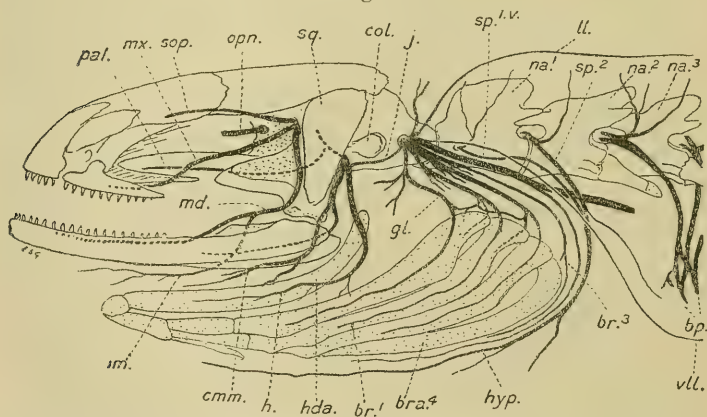
Before describing my own observations it will be well to give a brief account of the results obtained by previous workers. A good general description of the development of the skull of the Axolotl has been given by Parker (7). He describes the basilar plate, or floor of the cranium behind the pituitary fossa, as formed of a parachordal extension of the trabecular bars, combined with "proper occipital parachordals behind." The latter give rise to the occipital condyles; but their exact relation to the myotomes is not elucidated, although Parker notices that the glossopharyngeal ganglion lies behind the auditory capsule between the first and second myotomes. Stöhr (11) has given a very similar account of the development of the skull of *Siredon* (*Amblystoma*). Like Parker he found that the postpituitary region of the skull develops from three separate sources: the anterior parachordals ("Balkenplatten") derived from the trabeculae, the auditory capsules, and the occipital arches. By means of reconstructions of sections he made out clearly the origin of the posterior occipital arch. These arches, compared to vertebral arches, grow over the brain above, and along the sides of the notochord (occipital parachordals of Parker) join the backward extensions of the trabeculae ("Balkenplatten"), and enveloping the notochord form the basilar plate, which subsequently fuses with the auditory capsules. Stöhr, however, did not make out the exact position of the occipital element with regard to the nerves and myotomes.

Sewertzoff (9) was the first author to attack this problem directly. According to his account there are two metaotic somites, giving rise to two myotomes in the embryo (text-fig. 50, B, p. 116). The 1st disappears later. The 2nd, corresponding to the vagus, remains. Behind it, in the septum between the 2nd and 3rd, develops the occipital arch. The first trunk-segment

(3rd metaotic) has a myotome, a ventral root, but no ganglion. The next and succeeding trunk-segments are complete. That this description is incorrect has already been suggested by Miss Platt, who has given us a detailed and admirable account of the development of the head in *Necturus* (8).

Miss Platt analyses the postauditory region as follows:—The 1st somite belongs to the glossopharyngeal segment, develops no myotome and has no ventral root. The 2nd, 3rd, and 4th are vagus segments; the 2nd somite disappears ventrally, but its dorsal portion develops muscle which combines with the more fully formed myotome of the 3rd somite. The 4th and succeeding somites develop myotomes. The 3rd, 4th, and 5th grow down ventrally to give rise to the hypoglossal muscles, supplied by the ventral roots of the 4th and 5th segments. The 6th segment (3rd of the trunk) is the first to have a complete spinal nerve with ganglion, ventral and dorsal root. The first neural arch lies between the 4th and 5th somites. Between the 4th and 3rd somites appears the occipital arch marking the hind limit of the skull; while between the 3rd and 2nd somites is formed a rudimentary præoccipital arch, which is taken into the auditory capsule. If this account is correct, there are three metaotic segments in the head of Amphibia, the myotomes of the last two being represented in the adult by the anterior region of the dorsal temporal muscle.

Text-fig. 29.



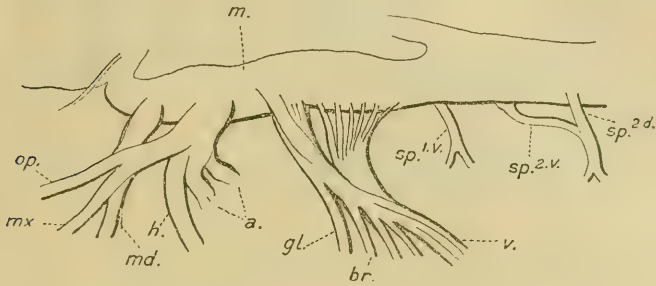
Dissection of a full-grown Axolotl, showing the skeleton and nerves of the head and three trunk-segments. The cartilage is dotted. View from left side.

Coming now to my own observations on *Amblystoma*, we may begin with a glance at the structure of the full-grown animal as shown in text-figs. 29 and 30*. The hyomandibular branch of the facial nerve issues from behind the otic process of the quadrate

* For explanation of the lettering of these text-figures see p. 120.

and the overlying squamosal, and passes down the hyoid arch. The glossopharyngeal and vagus come out together behind the auditory capsule—the former supplying the first branchial arch, and the latter giving off three branches to the remaining arches. A large visceral branch of the vagus runs along the alimentary canal, a

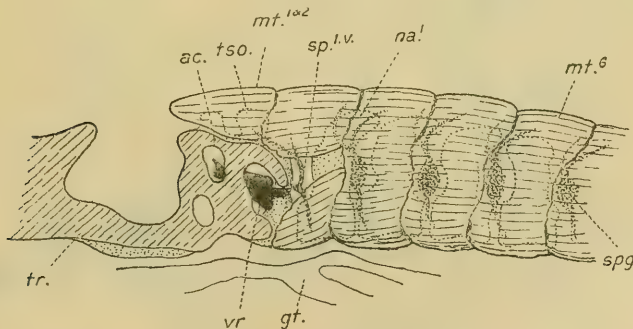
Text-fig. 30.



Outline of spinal cord and hind brain, with roots of cranial nerves and first two spinal nerves, seen from left side.

dorsal branch upwards, and slender lateral line branches to the skin. Through the bony neural arch of the first vertebra issues the first spinal nerve, having a ventral root only. Passing over the vagus it soon joins the complete second spinal, which has two roots*, and comes out behind the first vertebra. A dorsal twig of the first spinal supplies the temporal muscle. The first and second spinals together make up the hypoglossal nerve.

Text-fig. 31.

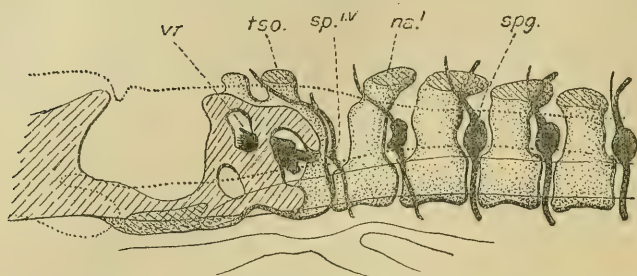


Partial reconstruction of the hind region of the skull and the anterior region of the trunk of an advanced larva with a head 6 mm. long. The cartilaginous skeleton and nerves are shown through the myotomes.

Text-figs. 31 and 32 are partial reconstructions of a larva which has nearly acquired the structure of the fully grown animal. The auditory capsule is chondrified and fused to the basilar plate,

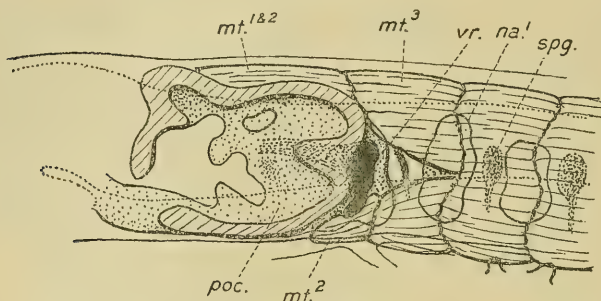
* Miss Platt finds only a ventral root to this nerve in *Necturus*. There can be no doubt that both roots are present in *Amblystoma* as well as a ganglion.

Text-fig. 32.

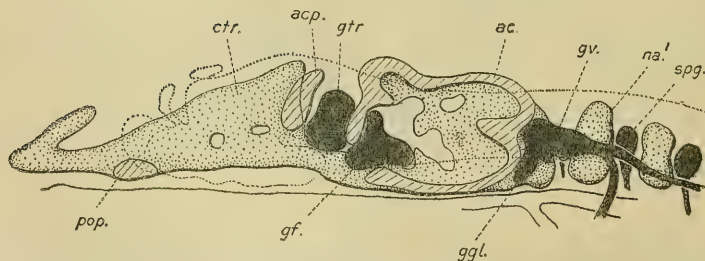


Partial reconstruction of the hind region of the skull and the anterior region of the trunk of the advanced larva shown in text-fig. 31. The myotomes have been removed.

Text-fig. 33.



Text-fig. 34.

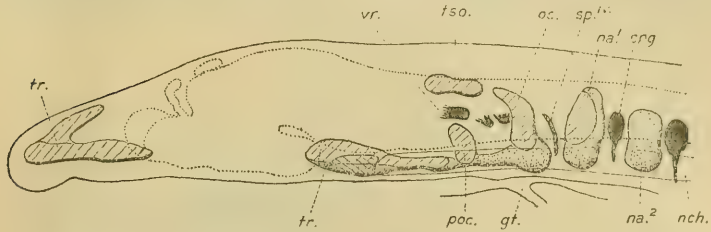


Partial reconstructions of the left side of the head region of a younger larva, in which a large amount of cartilage is developed.

Text-fig. 33 shows the inner wall of the auditory capsule, and the anterior myotomes of the trunk through which are seen portions of the skeleton and spinal nerves. The vagus nerves have been cut short at their exit from the skull. In text-fig. 34 the skeleton and nerves are more completely shown, but the muscles have been removed.

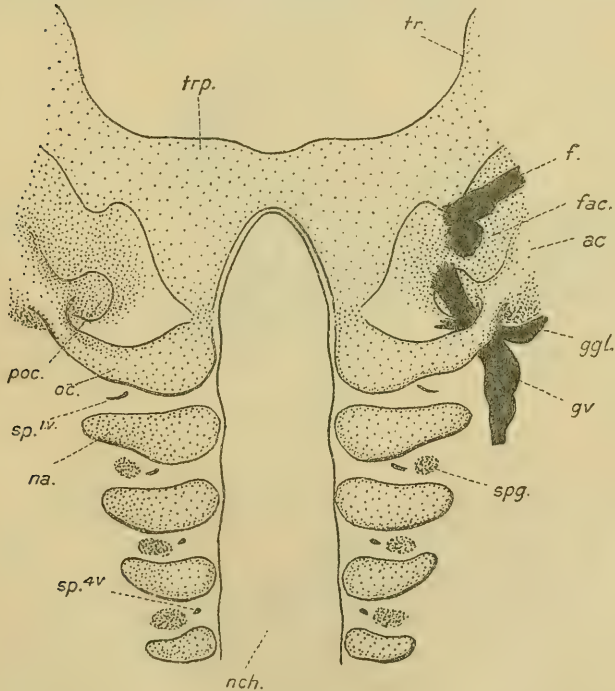
and the præoccipital and occipital arches. The latter is complete above the brain. The second muscular segment, really the third myotome developed in the 4th somite, is split in two by the vagus. The first hypoglossal nerve comes out between the skull and the first neural arch.

Text-fig. 35.



Partial reconstruction of the left side of the head region of the larva shown in text-fig. 34. Represents the same structures cut back to nearer the middle line, the auditory capsule and side wall of the skull being removed and the vagus roots exposed.

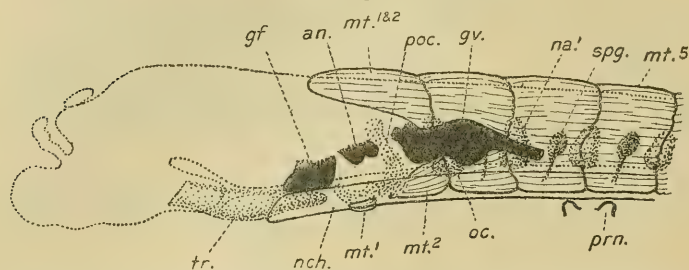
Text-fig. 36.



Reconstruction, seen from above, of the hind region of the skull, and anterior neural arches. Some roots of cranial nerves are seen on the right.

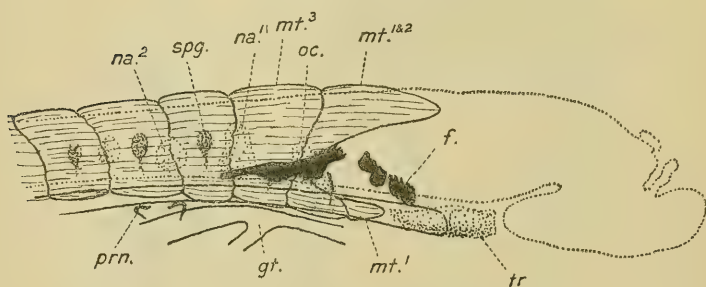
A larva slightly younger is shown in text-figs. 33, 34, and 35. At this stage the ventral portion of the 2nd myotome is still preserved. It lies below the vagus between the occipital and the præoccipital arches. The latter is seen to be a thickening in the inner wall of the auditory capsule, continuous below with the basilar plate (text-fig. 35). A reconstruction of a rather earlier stage seen from above (text-fig. 36) shows the capsule beginning

Text-fig. 37.

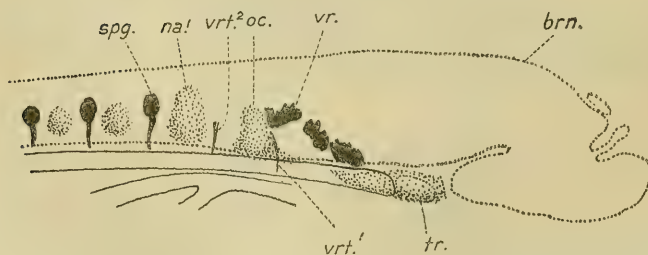


Left side view of a partial reconstruction of the anterior end. Cartilage is beginning to appear. The trabeculae have been cut short. The pronephric funnels are indicated in metaotic segments 5 and 6. The ventral portion of myotome 1 is still present.

Text-fig. 38.



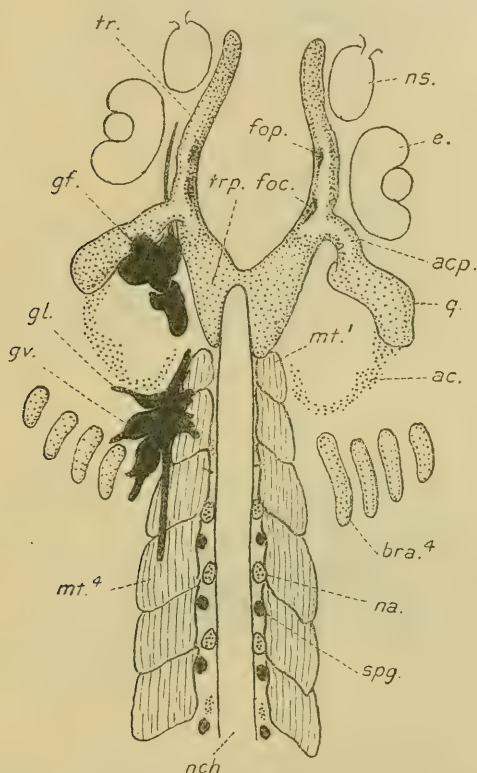
Text-fig. 39.



Partial reconstructions seen from the right side. In text-fig. 38 are the myotomes and pronephric funnels. The trabeculae have been cut short.

to chondrify behind; the occipital arch is fused on above the vagus. The floor of the skull widens out considerably from the occipital segment forwards to allow space for the brain, and the præoccipital arch is placed opposite the point where the occipital parachordal plate meets the anterior parachordal plate, a point not yet chondrified. Although it appears to chondrify in continuity with the auditory capsule, the præoccipital arch is probably serially homologous with the neural arches, as already suggested by Miss Platt.

Text-fig. 40.



Reconstruction, seen from above, of the head and anterior trunk-region. The dorsal ends of the gill-arches are shown, also the ventral region of the myotomes. Cranial nerve-roots are indicated on the right side.

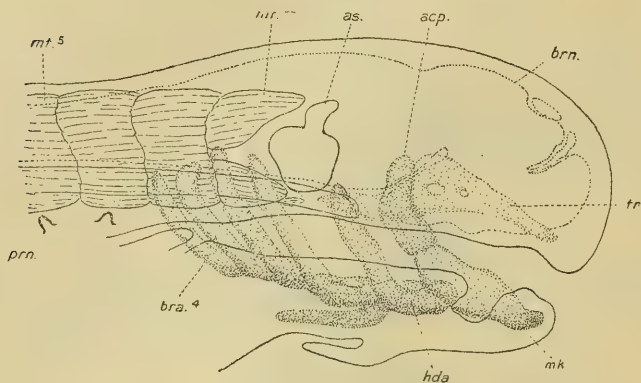
Its first appearance as a procartilaginous rudiment is seen in text-fig. 37, taken from a still younger larva, in the septum between the 2nd and 1st myotomes. At this stage the ventral portion of the first myotome (2nd somite) is still present. The auditory capsule itself is scarcely recognisable and quite without cartilage.

In the next younger stage, text-figs. 38 and 39, the præoccipital

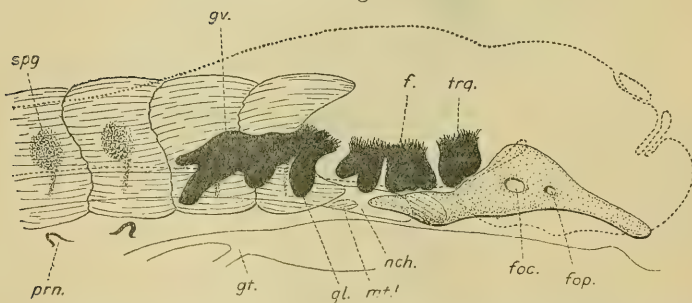
arch has not appeared, the ventral portion of the first myotome is larger, a ventral nerve-root is seen supplying myotome 2, and the neural arches are mostly in a procartilaginous state.

Text-fig. 40 is a partial reconstruction of another larva of about the same stage, but rather younger. The ventral portions of myotomes 1 to 6 are shown, also the spinal ganglia. Procartilage vaguely indicates the position of the auditory capsule, the occipital arch is scarcely yet marked out, but the next three neural arches

Text-fig. 41.



Text-fig. 42.

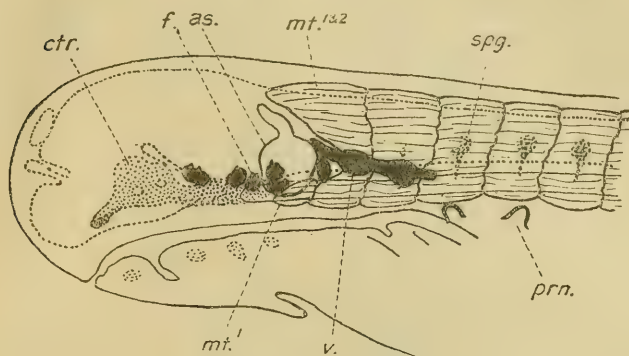


Reconstructions of the anterior region, seen from the right side. The visceral arches and auditory sac are seen in text-fig. 41; these have been removed in text-fig. 42, where the nerves are shown.

have begun to develop cartilage. The first myotome is quite, and the second myotome nearly, cut into a dorsal and a ventral portion by the roots of the glossopharyngeal and vagus. The ventral remnant of the first myotome (2nd somite) varies considerably in development, for in the younger larva drawn in text-figs. 41 and 42 it is hardly distinguishable. At this stage the trabeculae and visceral arches are the only skeletal elements visible, and true cartilage can scarcely be said to have appeared.

The next younger stage (text-fig. 43), again, shows a large ventral piece of the first myotome. At a still younger stage

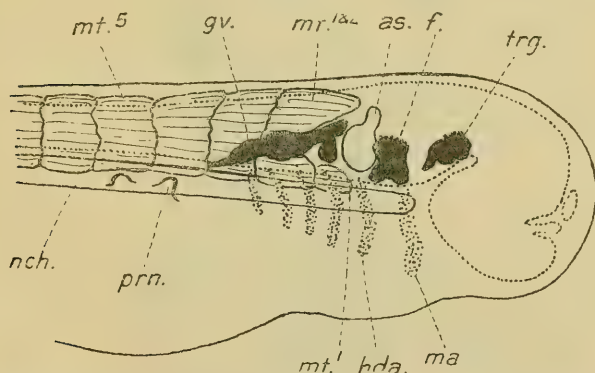
Text-fig. 43.



Left side view of a reconstruction of the anterior region.
The visceral arches are not completed.

(text-fig. 44), the trabeculae have not appeared and the visceral arches are represented by mere rods of procartilage.

Text-fig. 44.

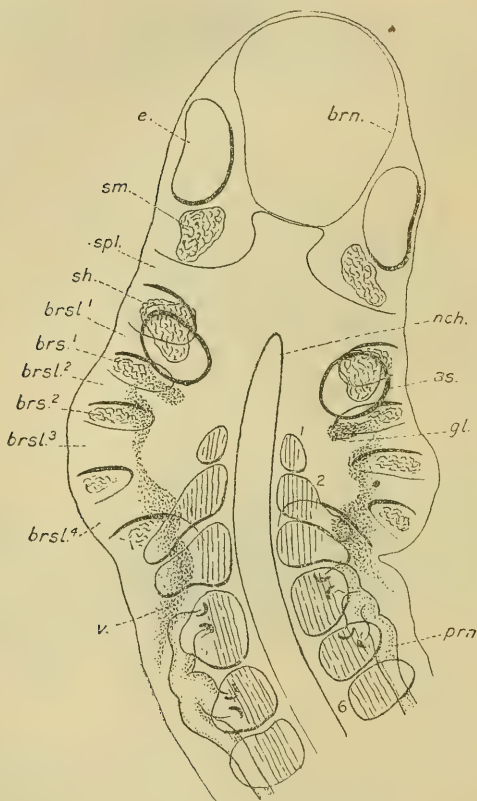


Right side view of a reconstruction of the anterior end of a larva in which the mesoblastic skeleton is represented only by procartilaginous rod-like visceral arches.

We now come to embryos without true mesoblastic skeleton. These earlier stages are most important in determining the number of postauditory segments. Text-figs. 45 and 46 are reconstructed from an embryo 5 mm. in length; they both are views from above, but text-fig. 46 reaches farther down, so as to include the alimentary canal and optic vesicles. Myotomes 4 and 5 are

clearly seen corresponding to the two pronephric funnels. Myotomes 2 and 3 give off diverticula passing behind the 4th branchial slit to form hypoglossal muscles. The ventral portion of the first myotome is some way behind the auditory vesicle and the rudiment of the hypoglossal ganglion. Below and in front of the vesicle is the hyoidean somite; while in front of the rudimentary spiracular gill-slit lies the mandibular somite.

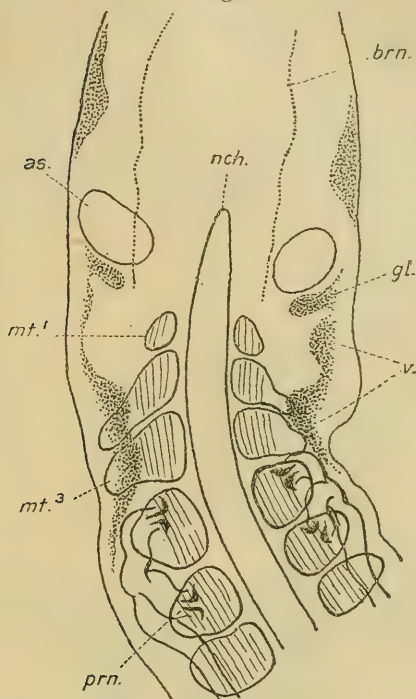
Text-fig. 45.



Partial reconstruction, seen from above, of the anterior region of an embryo in which the mesoblastic skeleton has not yet appeared. The epidermal thickenings corresponding to the glossopharyngeal and vagus nerves are indicated by dots.

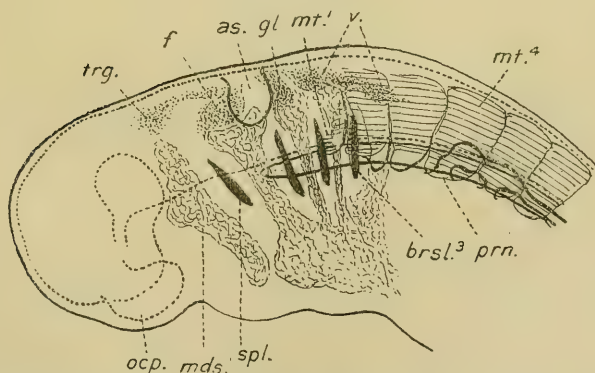
Another embryo of about the same length, but a little younger, is shown from the side in text-fig. 47. Here the auditory vesicle is still quite continuous with the epidermis, and the relation of the somites to the gill-slits is well shown. The slits are represented

Text-fig. 46.



Similar reconstruction of the more dorsal region of the same embryo as in text-fig. 45.

Text-fig. 47.

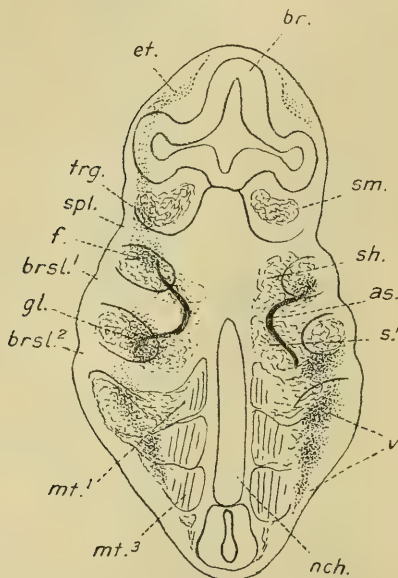


Left side view of a reconstruction of an embryo 5 mm. long. The cavities of the gill-pouches are shown in black. The auditory sac is a thickening directly continuous with the epiblast. Dots indicate epidermal thickenings. *PROC. Zool. Soc.*—1911, No. VIII.

in black, though not yet open. In front is seen the mandibular somite, below the rudiment of the trigeminal ganglion. Behind it lies the hyoidean somite, just in front of the vesicle and below the facial rudiment. Posterior to the vesicle is the glossopharyngeal rudiment, below which extends the first metaotic somite passing downwards into the first branchial arch. The vagus rudiment extends over the next two and part of the 4th somite; the first myotome is placed over the 2nd branchial arch.

Text-fig. 48 is a plan of a young embryo 3 mm. long, seen from the dorsal aspect, the nervous system being partly removed. The

Text-fig. 48.

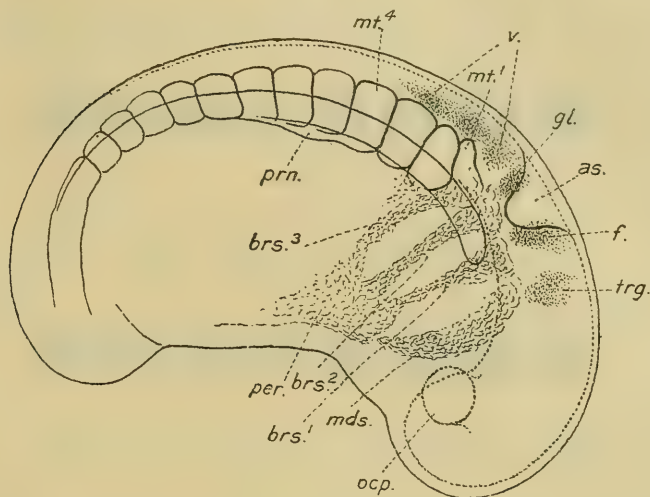


Partial reconstruction of the anterior region of an embryo 3 mm. long, seen from above. The greater part of the central nervous system has been removed to expose the alimentary canal, notochord, &c. The first and second metaotic somites overlie the first and second gill-arches.

position of the somite with relation to the other structures is much the same as in text-fig. 47. Lastly, in text-fig. 49 is drawn the youngest stage we need investigate. The dorsal portion of the 2nd postauditory somite has become closely pressed on to the 3rd somite, with which it remains intimately associated. Indeed, in the latter stages it is seen to be indistinguishably fused with it, the two combining to form the anterior region of that dorsal muscle which in combination with the 3rd myotome makes up the temporal muscle of the adult. Neither at this nor at any

other stage does the first metaotic somite produce muscle-substance.

Text-fig. 49.

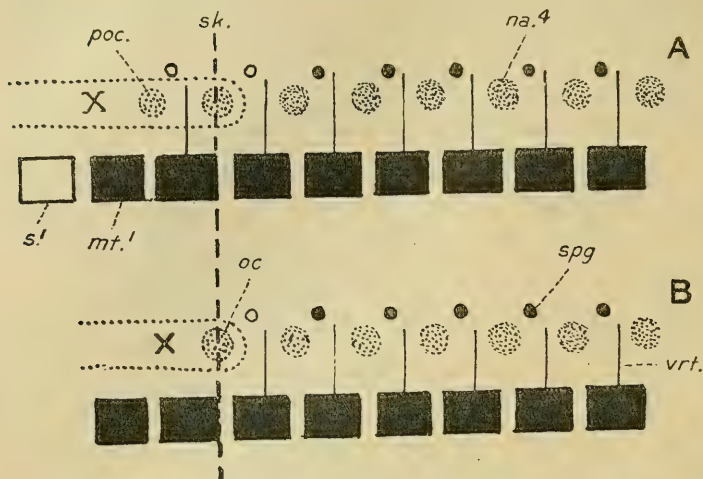


Right side view of a reconstruction of an embryo 3 mm. long. The first metaotic somite appears below the developing auditory sac and the glossopharyngeal epidermal thickening. The 2nd somite is closely applied to the 3rd.

Conclusions.

From the foregoing account it will be understood that in almost every particular my observations confirm the conclusion reached by Miss Platt in her study of *Necturus*. In *Amblystoma* as in *Necturus* there are three occipital segments. The first metaotic somite, however, disappears very early. Probably the examination of an insufficiently complete series of stages misled Sewertzoff (9) into the belief that there are only two metaotic somites; the first being either missed or later confused with the second. Gaupp, in his excellent review of the development of the skull (3), seems rather to favour Sewertzoff's interpretation. But if the diagram given by the latter, and reproduced by Gaupp, were correct, the second and third branchial rami of the vagus would lie outside the head area in the first two trunk-segments; and the third branchial ramus, passing behind the last gill-slit, would then belong to the second trunk-segment already provided with a complete spinal nerve possessing two roots and a ganglion. This is obviously not the case. The results of Sewertzoff and myself are compared in text-fig. 50. Only in unimportant details do my own observations differ from Miss Platt's. For instance, I find a ventral nerve-root in segment 3 and a dorsal root in segment 5. Moreover, the ganglion

Text-fig. 50.



Diagrams of the segmentation of the metaotic region in Amphibia:
B according to Sewertzoff, A according to my own observations.

of segment 4 seems to be early included in the rudiment of the vagus ganglia. Finally, text-fig. 51 represents what I believe to be the true composition of the Amphibian head.

Text-fig. 51.

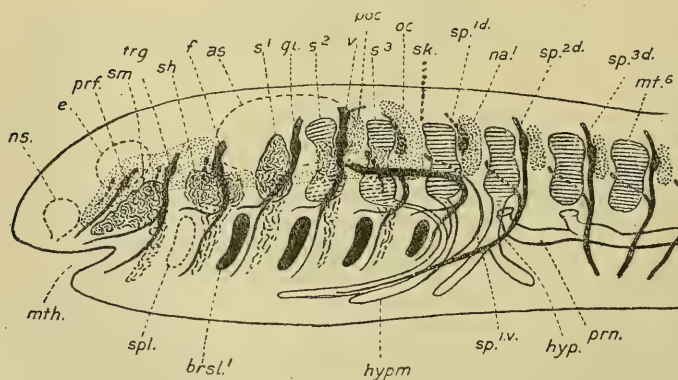


Diagram of the segmentation of the anterior region of an Amphibian.

We may now turn to the questions suggested on page 102. If any segments have been suppressed, it is apparently behind the vagus-root that they have been crushed out. Gegenbaur (4) believed the occipital arch to be a compound of several skeletal

segments, not the homologue of a single neural arch as Stöhr supposed. Fürbringer adopts much the same view in his great monograph (2), concluding that the occipital condyle of the Amphibia occupies the same segmental position as the last occipital segment in the Selachii. Many segments are supposed to have been crushed out between this and the vagus corresponding to the region in the Selachian skull through which pass the spino-occipital nerves. He claims, indeed, to have found possible traces of these segments in *Cryptobranchus*, where he discovered a small ventral nerve-root (z.) piercing the occipital bone. Miss Platt and Gaupp (8 and 3) are inclined to accept Fürbringer's view. Now the adoption by so many anatomists of the theory that a number of segments have vanished from the Amphibian head by a process of excalation is, I venture to think, based not so much on facts as on theoretical considerations. In the first place, there is a reluctance to admit that a structure like the occipital condyle can be homologous in two groups, although developed in different segments. But there can be no doubt that the homology of an organ is independent of its position in the segmental series.

The hind limbs of a Frog, an Axolotl, and an Amphiuma are homologous, in spite of the fact that they are placed in different segments. It is unnecessary here to recapitulate in full arguments which have already been given at length elsewhere (5, 6) with regard to the development of the fins of fishes. But I may briefly state:—That every trunk-segment is capable of producing limb-elements; that is to say, of contributing to the formation of median and paired fins. The shifting of a fin up or down the body is not due to the migration of fin-material from one place to another in the course of ontogeny; the fin, as a whole, arises from that region of the trunk which it occupies in the adult (as is shown by the development and the nerve-supply). Relative displacement in ontogeny is due almost entirely to "concentration," a relative narrowing of the base of the fin. Change of position in phylogeny is brought about by progressive reduction on one side, and growth on the other; apparent migration is due to certain segments beginning to contribute to the fin at one end and certain other segments ceasing to contribute at the other. By such "transposition" the fin may reach an entirely new position.

Now, in the case of the fins of fishes, I have already shown (5) that it is not possible to account for variation in position by the theory of inter- and excalation. Growth and transposition from one segment to another alone account for the facts. The same is probably true of the occipital condyle. There is not the slightest trace of the disappearance of segments behind the vagus in the ontogeny of the Amphibia. We are familiar with the variation in the extent of the gill-region in Vertebrates by mere growth. Obviously the hind limit of the series of gill-slits varies backward or forward, according as certain segments cease to

develop gills or take on the function of gill-formation. The posterior limit of the skull is doubtless altered in the same way, and the position of the occipital condyles may shift up or down the segmental series. There should, therefore, be no theoretical objection to accepting the anatomical and embryological evidence that the occipital region of the head in Amphibia contains only three segments. If segments could really disappear, leaving no trace behind, it would be hopeless to attempt to homologue segments in any two forms.

There is another theoretical consideration which seems to have led to the adoption of the view that the occipital region of the Amphibia is not as simple as it appears. It is urged that if it contained only three segments, the Amphibia would be more primitive than the Fishes from which they have descended. The possibility of the reduction in the number of occipital segments has just been explained above; but is there really any necessity to assume that it has taken place? From whatever Fishes the Amphibia may have been derived, we may be sure it was not from fully specialised Selachians. From palæontology alone we may hope to obtain definite evidence on this point; until contrary evidence is brought forward, there is no necessity to assume that the ancestors of the Amphibia had more than three differentiated occipital segments. Of all the living fishes the Dipnoi are those which most closely approach the Amphibia; even in the modern *Ceratodus* there is no occipital condyle, no distinct limit between head and trunk. It is true that several trunk-segments have here been more or less completely assimilated to the skull (Sewertzoff, 10); but there is no reason to believe that in the remote common ancestor of the Dipnoi and Amphibia the dividing-limit between the two regions could not have been developed three segments behind the auditory capsule. This seems to be in agreement with the conclusions of Agar (1), based on a study of the development of *Lepidosiren* and *Protopterus* *.

The hypoglossus in the Amphibia and Amniota may certainly be considered as homologous, although not necessarily composed of the same segmental nerves. It is owing to the shortness of the skull in the Amphibian that the hypoglossal roots come out behind it.

Summary.

The chief contents of this paper may be summarised as follows. Three occipital segments occur in the head of *Amblystoma*. Of the three somites developed in these, the first forms no muscle and disappears early; the second forms a myotome divided into dorsal and ventral portions, of which the former alone persists, fusing with the myotome next behind. The myotome of the third segment persists dorsally, that of the first trunk-segment

* The occipital region in fossil Amphibia seems to have been formed as in the modern species. Important evidence as to the assimilation of the hypoglossal segments in primitive Amniotes may perhaps be gleaned from a careful investigation of early fossil Reptiles. For instance, it seems to me not improbable that in *Pareiasaurus* the occipital region is still in an intermediate condition.

combines with it to form the temporal longitudinal muscle supplied in the adult by the first spinal nerve. The glosso-pharyngeal nerve belongs to the first metaotic segment and has no ventral root. To the second segment belongs the vagus root, with which seems to be combined the ganglia of the next two nerves. No ventral root was found in the second segment; but a ventral root occurs in the last metaotic segment in early stages of development. The first spinal issues from between the skull and first neural arch as a ventral root only; it joins the second spinal to form the hypoglossal nerve supplying muscles derived from ventral outgrowths of the second, third, and fourth myotomes. The basilar plate of the skull is formed by a backward growth of the trabeculae meeting a forward growth of the base of the occipital arches. It fuses with the auditory capsules, and with the præoccipital arches developed in the septum between the first and second myotomes. The occipital arches arise in the septum between the second and third myotomes. There is no evidence of the disappearance of segments behind the vagus, and no valid objection to the view that the hind limit of the skull may shift backwards or forwards in the course of phylogeny. At the same time there is no reason to suppose that the ancestors of the Amphibia had more than three occipital segments, when the occipital condyle became clearly defined.

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Explanation of Lettering on Text-figures.

<i>a.</i> , auditory nerve.	<i>ma.</i> , mandibular arch.
<i>ac.</i> , auditory capsule.	<i>md.</i> , mandibular branch of trigeminal.
<i>acp.</i> , ascending process of quadrate.	<i>mds.</i> , mesoblast of mandibular arch.
<i>as.</i> , auditory sac.	<i>mt.</i> , myotome 1-6.
<i>bp.</i> , branchial plexus.	<i>mt.</i> , mouth.
<i>br.</i> , branchial branch of vagus.	<i>mx.</i> , maxillary branch of trigeminal.
<i>brn.</i> , brain.	<i>na. 1.</i> , neural arch.
<i>brs.</i> , mesoblast of branchial arches 1-4.	<i>nch.</i> , notochord.
<i>brsl.</i> , branchial slit 1-4.	<i>ns.</i> , nasal sac.
<i>emm.</i> , median mandibular cutaneous branch of facial.	<i>oc.</i> , occipital arch.
<i>col.</i> , columella auris.	<i>ocp.</i> , optic cup.
<i>ctr.</i> , crista trabeculæ.	<i>opn.</i> , optic nerve.
<i>e.</i> , eye.	<i>per.</i> , pericardium.
<i>et.</i> , epiblastic thickening.	<i>poc.</i> , preoccipital arch.
<i>f.</i> , facial nerve.	<i>pop.</i> , preorbital process.
<i>fac.</i> , floor of auditory capsule.	<i>prf.</i> , profundus nerve.
<i>foe.</i> , oculomotor foramen.	<i>prn.</i> , pronephros.
<i>fop.</i> , optic foramen.	<i>q.</i> , quadrate.
<i>gf.</i> , facial ganglion and its epiblastic thickening.	<i>s. 1, 2, ...</i> , metaotic somite.
<i>ggl.</i> , ganglion of glossopharyngeal.	<i>sh.</i> , hyomandibular somite.
<i>gl.</i> , glossopharyngeal nerve and its epiblastic thickening.	<i>sk.</i> , hind limit of skull.
<i>gt.</i> , glottis.	<i>sm.</i> , mandibular somite.
<i>gtr.</i> , ganglion of trigeminal and its epiblastic thickening.	<i>sop.</i> , superior ophthalmic nerve.
<i>gv.</i> , ganglion of vagus and its epiblastic thickening.	<i>sp. 1.</i> , first spinal nerve.
<i>h.</i> , hyomandibular branch of facial.	<i>sp. 2d & v.</i> , second spinal nerve, dorsal and ventral root.
<i>hda.</i> , hyoid arch.	<i>spg.</i> , spinal ganglion.
<i>hyp.</i> , hypoglossal nerve.	<i>spl.</i> , spiracular slit.
<i>hypm.</i> , hypoglossal muscle.	<i>spvr.</i> , ventral root of spinal nerve.
<i>im.</i> , internal mandibular branch of trigeminal.	<i>tr.</i> , trabecula cranii.
<i>j.</i> , anastomosis of Jacobson.	<i>trg.</i> , trigeminal ganglion.
<i>ll.</i> , lateral line nerve.	<i>trp.</i> , trabecular parachordal.
<i>m.</i> , medulla.	<i>tso.</i> , tectum synoticum.
	<i>v.</i> , vagus nerve.
	<i>vll.</i> , ventral lateral line nerve.
	<i>vr.</i> , roots of vagus and glossopharyngeal.
	<i>vrt.</i> , ventral root.

9. The Mammals of the Tenth Edition of Linnæus ; an Attempt to fix the Types of the Genera and the exact Bases and Localities of the Species. By OLDFIELD THOMAS, F.R.S., F.Z.S.

[Received November 29, 1910: Read December 13, 1910.]

The tenth edition of Linnæ's 'Systema Naturæ' is the recognized basis and commencement of all systematic zoological work, but doubtful questions in its interpretation are very numerous, and there is probably nothing more desired, by mammalogists at least, than a methodical examination of this important work, with suggestions, obtained on some definite and uniform system, for the identification of its types, both of genera and species.

For many years I have taken a very great interest in this subject, and have now ventured to prepare the present paper, with the hope that it may be of service to other mammalogists less favourably situated as regards books and specimens than I have

the privilege of being. For in all the work I have scarcely in a single instance been unable to obtain from the library of the Natural History Museum what books I have wanted to verify Linnæus's quotations, however rare and obscure they have been. Without such an advantage it would have been impossible to do the work at all.

With regard to the method used for finding the type-species of the Linnean genera, I would draw attention to the very considerable extent to which the principle of tautonymy is available. In a great proportion of cases Linnæus selected as a generic name a term which had been used by earlier writers for the single name of a member of the genus, so that among the species of any given genus there is commonly one which has among its synonyms the name used by Linnæus for the genus.

These names are generally quoted from Gesner, and comprise the most conspicuous and best-known members of each genus, so that in nearly all cases the genotype selected on this system is the very one which by general consent we should wish to have for the type. Any other rule that has been suggested, either "first species" or "elimination," is liable to produce results by no means so satisfactory—indeed, the many objections to both are too well known to need any insistence upon here. Nor can any later and arbitrary selection of types without reason assigned be taken as necessarily valid.

In two cases only, those of *Simia* and *Dasypus*, are results arrived at different from those obtained by previous writers. The shifting of the latter name from the rarer "*Euphractus*" to the really common *Tatusia* is unfortunate, but is necessary if we are to get the benefit of the general stability which is obtainable from the acceptance of the principle of tautonymy.

The case of *Simia*, however, is very different, and I confess to hoping that the suggestions which are now being made for some overruling decision in the case of certain well-known but technically misapplied names may be carried out, both as to a number of such names in general and to *Simia* in particular.

But it seems advisable, nevertheless, to put the technical case irrespective of the prospect of any such decision, and therefore (while hoping that a fiat attaching *Simia* to the Orang may go forth) I have to point out that this name should be applied to the Macaques, with *S. sylvana* (the Barbary Ape) as its type, while *Anthropopithecus* will remain available for the Chimpanzees.

Should no such fiat as I speak of ever come to pass, this allocation of *Simia* is at least better than its application to the Chimpanzees. Not only is it less confusing in itself, owing to the consequent total abolition of the combination *Simia satyrus*, connected for a century with the Orang, but now sought to be applied to the Chimpanzee, but also the genus to which it goes, that of the Macaques, is already marked as the victim of a nomenclatural change, for *Pithecus* antedates *Macaca*, and therefore one change is not much worse than the other.

Moreover, the Macaques are far less often dealt with or spoken of by outside writers, not up to date in nomenclatural technicalities, than are the Anthropoid Apes, among whom such a change has the maximum of inconvenience.

[After the completion of the present paper, there has come into my hands a copy of the "Opinions rendered by the International Commission on Zoological Nomenclature," dated July 1910, but received by members of the Gratz Congress only at the end of October.

In this publication the question of Linnean Genera in general and *Simia* in particular is dealt with, certain conclusions are come to not differing widely from my own, and the principle of tautonymy as applied to the names in Linnæus is on the whole approved of.

Two genera (*Mus* and *Camelus*) have types definitely fixed for them, twenty are mentioned as "seeming to retain as types" the species I fix for them by tautonymy, though this is "not a ruling by the Commission," and *Dasyppus* is ignored.

With regard to *Simia*, the Commissioners, while seeing that the rule brought the type on to *sylvanus*, would appear to have thought it a benefit for zoology that *satyrus* should be considered as such, an opinion in which I believe but few zoologists on careful consideration would be found to agree with them. Under this idea a brief but rather far-fetched and unconvincing argument is adduced to avoid the simple conclusion about *sylvanus*, viz. :—that "an examination of Gesner's text shows that he did not use *Simia* in the specific sense of 'the *simia*,' and that therefore *Simia* Gesner, as used in the synonymy of *S. sylvanus*, cannot be considered as the name of a species."

Now I have carefully examined Gesner (three editions, including that quoted), and can only say that his use of *Simia* is exactly the same as his use of other names which are accepted as tautonyms. On p. 847 he writes "de *Simia*," and gives a figure of the Barbary Ape, and then on p. 855 he begins on other monkeys under the heading "de *Simiis diversis*." Exactly in the same way we have "de *Mure*" on p. 714 (*Mus musculus*) and "de *Muribus diversis*" on p. 731; "de *Mustela*" on p. 752, "de *Mustelis diversis*" on p. 762.

It is true that the Commissioners do not definitely accept as a ruling of the Commission the above-mentioned twenty names on the rigid basis of tautonymy, but seem to take as valid Palmer's selection of the types as published in his Index (1904).

But the latter work cannot be accepted as that of a "reviser" in the true sense of the term. It is merely a bibliographical work giving an indication of what species have been currently accepted as types, without special revision by authors with all the facts before them. In no case could I admit that it should override the clear case for tautonymy presented by *Simia* equally with the twenty genera in which its results are agreed to both by Palmer and the Commissioners.]

The question of the species is not so simple as that of the genera, having been complicated by the pages and pages which commentators have thought it necessary to write balancing the pros and cons in each case, weighing the importance of this reference or that, and deciding that such and such is the "primary quotation" and should be taken as the basis of the Linnean name. This balancing method, however charming an exercise of the writer's ingenuity it may provide, is unfortunately full of the personal equation, and therefore objectionable, while any method which works automatically should be welcomed by those desirous of coming to a final and impersonal decision on such points.

The system I advocate is that Linnæus's quotation of his own earlier writings should be given an absolutely overriding importance, and that, where these exist and can be traced back, all others should be ignored.

This principle is not an arbitrary one, but is quite reasonable. For when in 1758 Linnæus gave a binomial name to an animal to which he had already given in 1748 a species-number and a diagnosis (quoting it in the tenth edition), his idea of the species would clearly have been formed at the earlier date, the later edition only adding the binomial name. To accept as of primary importance in the determination of the latter some reference which was not in existence at the time of the earlier edition appears to me little short of ridiculous.

But if we take Linnæus's own Linnean quotations—which are, in most cases, of the sixth edition—we get our field of selection narrowed down at once to one or two easily traceable references, from which the basis of the author's original idea of each species is readily obtainable.

So important did Linnæus himself think the sixth edition that practically every species of Mammal in it is quoted in the tenth, and that merely by its page and number, as if that were the one edition to which attention should be paid.

Curiously enough, this does not seem to be the case in other groups than Mammals, the references to the sixth edition being omitted, and primary stress laid on the 'Fauna Suecica.'

With regard to type localities, I have made every effort to identify the places from which the specimens came that were the original bases of Linnæus's names. His own statements of habitat are for the most part too vague to be of any use, while accepting them literally would sometimes lead to grotesque errors, such as the assertion, based on Linnæus's "*Hab. in Indiis*," that "some Indian Armadillo" (!) should be taken as the basis of *Dasypus septemcinctus*. "In Indiis," in fact, hardly amounts to more than a statement that the species is exotic.

But many localities can be settled from the authors quoted, as, for example, in the case of Marcgrave, on whose descriptions* Linnæus's names for a large number of the commoner Brazilian

* 'Historiæ Rerum Naturalium,' Brasiliæ, 1648.

species were based. With all these we are able to fix as a type locality Pernambuco, for Marcgrave stayed at "Moritzstadt," now Recife, most of his time, 1640-1644, while, even his excursions were limited to the coast region between 5° 45' and 11° 11' S., thus taking in little more than from Rio Grande do Norte to Alagoas, a region at the centre of which Pernambuco lies.

Again, with regard to species named from the figures in Seba's 'Thesaurus,' it would not be unjustifiable to suggest that in the case of all tropical South American animals, Surinam—the great source of all Dutch collections—should be accepted as the type locality, except when the preservation of the type specimen or some incompatibility in the description shows this to have been impossible.

The alterations in nomenclature that have proved to be necessary are fortunately comparatively few, certainly far fewer than I had originally feared would be the case. Those not previously published are the following:—

- Simia*. Genotype not *satyrus* but *sylvanus*. p. 125.
Anthropopithecus satyrus for Chimpanzee. p. 125.
 Technical name of Barbary Ape, *Simia sylvana*. p. 125.
Pygathrix a distinct genus from *Presbytis*. p. 127 (footnote).
Macaca syrichta for *M. philippinensis* auct. p. 129.
Manis pentadactyla for *M. dalmani* Sund. p. 133.
Dasypus for *Tatu*; *Euphractus* for "*Dasypus*." p. 141.
Arvicanthus striatus for *A. pulchellus* Gray. p. 148.
Physeter catodon for *Ph. macrocephalus* Linn. p. 157.

Other names here confirmed, which are unfamiliar, though not now published for the first time, are those indicated for the Whalebone Whales by Mr. F. W. True, those of certain monkeys (Cebus, Mandrill, &c.), recently pointed out by Dr. Elliot, *Presbytis aygula* for *P. mitratus*, *Cynocephalus volans* for the Philippine Colugo, *Elephas maximus* for the Indian Elephant, and *Myrmecophaga tridactyla* for *M. jubata*.

In one respect the present paper does not complete the examination of all the Linnean 1758 species, for a certain number are still unidentified pending the study of typical specimens formerly in the "Museum Regis Adolphi Friderici," and no doubt in many cases still in existence. I would commend to my colleagues in Sweden an examination of the old collections there preserved, with an identification of such types as are still extant. Perhaps Dr. Einar Lönnberg may be able to forward this final completion of the study of the "Zoological Bible" written by his immortal compatriot.

In the following pages the genera and species are arranged as in the 'Systema,' while opposite the name of each species on the right-hand side of the page I have placed the name of the recognized modern genus into which that species falls.

Genus 1. HOMO. p. 20.

Two species. Type, *H. sapiens*.

Species :

1. SAPIENS. p. 20.

Homo.

“Nosce te ipsum.”

2. TROGLODYTES. p. 24.

A mixture of the abnormal hairy woman figured by Bontius (Hist. Nat. Med. Ind. Or. p. 84) with an account of albino negroes taken from Nils Matson.

Genus 2. SIMIA. p. 25.

Twenty-one species. Type by tautonymy: *S. sylvanus* (“Simia,” Gesn.).

The species are divided into three sections, (1)* *Cauda nulla*: *Simiæ veterum*, (2)** *Cauda abbreviata*: *Papiones*, and (3)*** *Cauda elongata*: *Cercopithecæ*.

From the name “*Simiæ*,” the type must clearly be sought among the first section, which contains two species, *satyrus* and *sylvanus*, and the second of these (*not the first*) should be taken as type, because among its synonyms—the first, in fact—occurs “*Simia*, Gesner, p. 847” (of 1620 edition, 957 of 1551 edition, p. 1 of German edition).

From this it would follow that, failing a fiat on the subject, the generic name *Simia* should be transferred—not to the Chimpanzee, as has been done by Matschie and Rothschild, but to the Barbary Ape and its congeners.

Species :

1. SATYRUS.

Anthropopithecus.

Linnean reference: Syst. Nat. (6) p. 3, no. 1, where the first quotation is

Tulp. Obs. p. 270, pl. xiv.

Clearly the Common Chimpanzee*, whose name (again failing a fiat) would therefore be *Anthropopithecus satyrus*.

2. SYLVANUS. p. 25.

(*Simia* or) *Macaca* †.

Linnean reference: Syst. Nat. (6) p. 3, no. 3, where the sole reference is to

Alpin. Aegypt. p. 241, pl. xvi.

This is clearly a Barbary Ape, to which therefore, instead

* Cf. W. Rothschild, P. Z. S. 1904, ii. p. 420.

† I continue to use *Macaca* provisionally, pending a decision as to “fiat” names. To use *Pithecus* (although it antedates *Macaca*) would be merely the commencement of a useless familiarity with that name, which would be again overthrown should the fiat principle fail.

of *Macacus* (or *Macaca*) *innus* or *Innus ecaudatus*, the name *Simia sylvana* would appear to be technically applicable.

The reference *Simia sylvanus* has been already frequently put among the synonyms of *Macaca inua*, so that the present identification is not a new one.

3. SPHINX. p. 25.

(*Mandrill* *.)

Linnean reference: Syst. Nat. (6) p. 3, no. 5, where the sole reference is to Ray (Quadr. p. 158), who in turn speaks of the "Baboon Gesnero descripta et depicta."

This is, no doubt, as shown by Dr. Elliot †, the Mandrill, of which a figure and description are given on the page between 157 and 158 of Gesner's German edition (1606).

4. APEDIA. p. 25.

(?)

Linnean (and sole) reference: Amœn. Acad. i. p. 278 (1749).

Not determinable from description, but if the specimen described in the 'Amenitates' as being in the Museum Adolpho-Fridericianum still exists, the species may yet be identified.

Type locality "in Indiis," which means hardly more than "foreign." No locality at all is mentioned in the 'Amenitates.'

5. SILENUS. p. 26.

Macaca.

No definitive reference, the only one, that to Alpinus (p. 242), being with a query, so that the account should be treated by its own evidence only.

The description and locality, however, appear to me to be sufficient to assign the name to the Malabar "Lion-tailed Monkey of Pennant," as was done by practically every author up to Blanford.

That author, working on the basis of the 12th edition, first stated ‡ that the name did not refer to the Lion-tailed Monkey, and then later on used it for it §.

No exact typical locality available.

6. FAUNUS. p. 26.

(?)

Linnean reference: Syst. Nat. (6) p. 3, no. 15, whence we get *Cercopithecus barbatus*, no. 1, Clusius, Exot. p. 371 (1605).

It does not seem possible to determine this monkey with any certainty. In the pointed white beard and white chest we have something which suggests the Diana Monkey, while, on the other hand, by the length of the beard (if mantle-hairs were mistaken for a beard) and the tufted tail a *Colobus* of some sort might be indicated.

No locality given.

* As Palmer has shown, this is the technical name for the Mandrill, if considered generically distinct from other Baboons, as it apparently should be.

† Ann. Mag. N. H. (8) iv. p. 417, 1909.

‡ P. Z. S. 1887, p. 620.

§ Mamm. Ind. p. 16, 1888.

7. PANISCUS. p. 26.

Ateles.

Linnean reference: Syst. Nat. (6) p. 3, no. 14, whence
Guariba, Marcgr. Bras. p. 226.

Ateles paniscus.

Type locality: Pernambuco.

8. DIANA. p. 26.

Cercopithecus.

Linnean reference: Act. Stockholm, 1754, p. 210, pl. vi.

Here a full description of the monkey is given, and, as Jentink * has pointed out, it is the red-thighed form to which the name *diana* was originally applied.

Type locality: "Guinea."—Liberia (Jentink).

9. CEPHUS. p. 27.

Cercopithecus.

No Linnean reference. Quotations of Marcgrave (p. 228)
and Ray (p. 156).

Type locality: "Guinea."

10. AYGULA. p. 27.

Presbytis †.

No Linnean reference. Sole basis: "Osb. iter. 99" (= Osbeck,
Ostindisk Resa, p. 99, 1757).

Type locality: Java.

The species usually known as *P. mitratus* Eschsch. (see Thos.
& Wrought. P. Z. S. 1909, p. 373).

11. HAMADRYAS. p. 27.

Papio.

Linnean reference: Syst. Nat. (6) p. 3, no. 7, where the sole
reference is to Alp. Aegypt. p. 242, pls. xvii. & xviii.

Hamadryas Baboon.

Type locality: Egypt.

12. JACCHUS. p. 27.

Callithrix.

Linnean reference: Syst. Nat. (6) p. 3, no. 12, whence Cagui
minor, Marcgr. Bras. p. 227 (misquoted 228).

Common Marmoset.

Type locality: Pernambuco.

13. ŒDIPUS. p. 28.

Leontopithecus.

No Linnean reference. Sole basis: Edwards, Aves, iv. p. 195,
pl. 195, 1751.

Type specimen said to have been brought from "Vera Cruz, in
New Spain," but the species does not occur there.

* Notes Leyd. Mus. xx. p. 233, 1898.

† Dr. Elliot (Bull. Am. Mus. N. H. xxviii. p. 151, 1910) has recently pointed out that the name *Pygathrix*, based on *Simia nemæa*, antedates *Presbytis*, and should be used instead of it. But an examination of the skulls convinces me that *nemæa* and its close ally *nigripes* are, as Gray said, generically distinct from all the other Langurs, which would therefore retain the name *Presbytis*. The basal axis of the brain-case is set on to the facial bones at quite a different angle in the two genera,

14. ETHIOPS. p. 28.

Cercopithecus.

Linnean reference: Linn. in Hasselquist, Iter, p. 190, 1757.

Formerly known as *C. griseoviridis*.

See de Winton, in Anderson, Mamm. Egypt, p. 15, 1902.

Type locality: Upper Egypt.

15. MIDAS. p. 28.

Leontopithecus.

No Linnean quotation. First and primary reference:

Edwards, Aves, iv. p. 196, pl. 196, 1751.

Locality: "West Indies."

16. CYNAMOLGOS *. p. 28.

Papio.

Linnean references: Syst. Nat. (6) p. 3, no. 10 (ex Marcgr.

Bras. p. 227), and *Simia ægyptiaca*, Linn. in Hasselq. Iter,

p. 189, 1757.

Both these references being Linnean, the one that refers to an actual specimen should be taken in preference to that merely based on Marcgrave's short and indefinite notice.

Consequently *Simia cynamolgus* becomes a synonym of *Papio hamadryas*.

Type locality: Upper Egypt.

17. APELLA. p. 28.

Cebus.

Linnean reference: Mus. Ad. Frid. p. 1, pl. i., 1754.

Cebus capucinus auctorum.

See Elliot, Bull. Am. Mus. N. H. xxvi. p. 227, 1909.

No type locality available, but Guiana may be accepted from later authors.

18. MORTA. p. 29.

Saimiri.

Sole basis: Seba, Thes. i. p. 52, pl. xxxiii. fig. 1, 1734.

Clearly a Squirrel-Monkey, but as the species is not determinable the name must lapse.

The suggestion that Surinam should be taken as a typical locality for Seba's animals cannot be adopted in this case, as the statement that *Simia morta* had the back of the head blackish is inconsistent with the condition found in the Guianan species.

19. CAPUCINA. p. 29.

Cebus.

Linnean reference: Mus. Ad. Frid. p. 2, pl. ii., 1754.

The monkey usually known as *C. hypoleucus* Humb.

See Elliot, Bull. Am. Mus. N. H. xxvi. p. 227, 1909.

No type locality available. The species is Central American and Colombian.

being far more strongly inclined in *Pygathrix*, in which, as a consequence, the posterior nares are of enormously greater height. Gray, following Dahlbohm, separated the two on external characters and the proportions of the fore and hind limbs, and my comparison of the skulls quite confirms his judgment in the matter.

* Spelling altered to *cynomolgus* in 32th edition.

20. SCIUREA. p. 29.

Saimiri.

Linnean reference : Mus. Ad. Frid. i. p. 3, 1754.

Common Squirrel-Monkey.

The Guianan form, which agrees with the description, may be accepted as typical.

21. SYRICTHA. p. 29.

*Macaca.*Linnean reference : Syst. Nat. (6) p. 3, no. 6 ; whence we get "Cercopithecus *Luzon. minimus* D. Camel," Petiver, Gazophylacium, pl. xiii. fig. 11. No. 176 of Index.This figure—although a ghastly travesty in itself—can be nothing but the one monkey found in Luzon, viz., *Macaca philippensis*, *philippinensis*, or *palpebrosus* auctorum, which names should give way to that of *M. syrichta*.Type locality : Luzon (probably Southern Luzon, whence Dr. Camel sent "*Lemur volans*").

Genus 3. LEMUR. p. 29.

Three species, no one with "Lemur" as a subsidiary name.

Type, *L. catta* ; *L. tardigradus* having been made the type of *Loris*, Geoff., 1796, and *L. volans* of *Cynocephalus*, Bodd., 1768 (= *Galeopithecus*, Pall., 1780).All authors have accepted *L. catta* as the type of *Lemur*.

Species :

1. TARDIGRADUS. p. 29.

Loris.

Linnean references : "Mus. Ad. Fr. i. p. 3 ; Syst. Nat. (6) p. 5 *, no. 2."

The specimen referred to in Mus. Ad. Frid. and redescribed in the 10th edition is still in the Stockholm Museum, and, as Dr. Lönnberg informs me, is the Cinghalese Slender Loris. It may even have been the specimen figured by Seba, who is quoted in the 6th edition.

See also Thos. Ann. Mag. N. H. (8) i. p. 467, 1908, where the same conclusion is reached on the ordinary "Linnean reference" grounds.

Type locality : Ceylon.

2. CATTA. p. 30.

Lemur.

Sole basis : Simia—Sciurus madagascariensis, sive Maucauco, Edwards, Aves, 119, t. 199.

The Ring-tailed Lemur.

3. VOLANS. p. 30.

Cynocephalus.

References :—

Cato—Simius volans camelli, Pet.(iver), Gaz.(ophylacii Naturæ et Artis), t. 9. f. 8 (1702); Act. Angl. 277,

* Misprint for 3.

p. 1065 (= Phil. Trans. Roy. Soc. pt. 277, included in vol. xxiii. 1704).

Vespertilio admirabilis, Bont.(ius), Java, p. 68, 1658.

Felis volans ternatia, Seba, Mus. i. p. 93, t. 58. f. 2, 3.

The first is the primary and only vital reference, as the others refer to specimens from impossible localities (Guzerat and Ternate).

Petiver's type locality was Pampanga, Southern Luzon, and the animal therefore was that until recently known as *Galeopithecus* (or *Colugo*) *philippinensis*.

Cynocephalus, Boddaert, was based on "*Lemur volans* Linn.," and antedates *Galeopithecus* by many years.

See Thos. Ann. Mag. N. H. (8) i. p. 252, 1908.

Genus 4. VESPERTILIO. p. 31.

Seven species, of which no. 7, *murinus*, has among its synonyms *Vespertilio*, Bell. Av. 147; Gesn. Av. 694.

Therefore type by tautonymy: *Vespertilio murinus* L., the bat formerly known as *V. discolor*.

See Miller, Ann. Mag. N. H. (6) xx. p. 379, 1897.

Species :

1. VAMPYRUS. p. 31.

Pteropus.

Linnean reference: Syst. Nat. (6) p. 7, no. 1.

There the only reference is to

Canis volans ternatanus orientalis, Seba, Thes. i. p. 91; t. 57. f. 1, 2.

Pteropus edulis auctorum.

See Thos. P. Z. S. 1892, p. 316.

Type locality: Ternate. A co-type in British Museum.

2. SPECTRUM. p. 31.

Vampyrus.

Only reference: *Canis volans maxima aurita*, Seba, Thes. i. p. 92, t. 58. f. 1.

Species known rightly as *Vampyrus spectrum* L.

Suggested type locality: Surinam.

3. PERSPICILLATUS. p. 31.

Hemiderma.

Linnean references: Syst. Nat. (6) p. 7; Mus. Ad. Fr. i. p. 7.

The latter, as referring to an actual specimen, would take precedence, but the description is unrecognizable, and no specimen is now in existence, as Dr. Lönnberg informs me. We therefore take the single reference of the 6th edition:—*Vespertilio americanus vulgaris*, Seba, Thes. i. p. 90, t. 55. f. 2, of which the original specimen (B.M. no. 67.4.12.597) is the bat known until 1892 as *Hemiderma brevicauda*.

See Thos. P. Z. S. 1892, p. 316.

Suggested type locality: Surinam.

4. SPASMA. p. 32.

Megaderma.

The Linnean reference (Syst. Nat. (6) p. 7) refers alone to

Glis volans ternatanus, Seba, Thes. i. p. 90, p. 56. f. 1, which is the bat known as

Megaderma spasma.

See K. Anders. & Wrought. Ann. Mag. N. H. (7) xix. p. 132, 1907.

5. LEPORINUS. p. 32.

Noctilio.

Equally through Syst. Nat. (6) p. 7, the first Linnean reference, and Seba, pl. lv. fig. 1, we get to the correctly known

Noctilio leporinus.

Suggested type locality: Surinam.

6. AURITUS. p. 32.

Plecotus.

References: Frisch, Av. (Vögel Deutschlands) 103.

Edw. Av. t. 201. f. 3.

Olear. Mus. t. 15. f. 1.

The Long-eared Bat, *Plecotus auritus.*

Type locality, from Frisch: Germany (Berlin).

7. MURINUS. p. 32.

Vespertilio.

Linnean references: Faun. Suec. 18; Syst. Nat. (6) p. 7, no. 2.

For reasons explaining why this should be considered as the bat formerly known as *Vespertilio* or *Vesperugo discolor*, see Miller, *l. c.*

Type locality: Sweden (Upsala).

Genus 5. ELEPHAS. p. 33.

Monotypic. Type, *E. maximus* (*E. indicus* auctorum).

Species:

MAXIMUS. p. 33.

Elephas.

Linnean reference: Syst. Nat. (6) p. 11, where the single quotation is to Ray, Quadr. p. 123 (131 in the Museum copy).

Ray gives a long account of the Elephant, but does not distinguish the two forms, nor give any locality. Linnæus, however, says "Habitat in Ceylonæ paludosis," whence

Type locality: Ceylon.

Genus 6. TRICHECHUS. p. 34.

Monotypic. Type, *T. manatus.*

Species:

MANATUS. p. 34.

Trichechus.

Linnean reference: Syst. Nat. (6) p. 39 (misprinted 37).

Single reference in 6th edition: Artedi, Synonym. 109 (misprinted 107).

Artedi here, again, gives a primary reference to his own 'Genera

Piscium,' no. li. p. 556, where we find a general account which includes both Manatees, American and African, and Dugongs. Linnaeus, however, puts "in mare americano" as locality, and this would fix the name on the common American species.

Type locality: West Indies.

Genus 7. BRADYPUS. p. 34.

Two species. Type by selection: *B. tridactylus*. Selected by Illiger, who at the same time eliminated *B. didactylus* as a *Cholepus*.

Species:

1. TRIDACTYLUS. p. 34.

Bradypus.

First Linnaean reference: Syst. Nat. (6) p. 3.

Two references: Seba, Thes. i. t. 33. f. 2, and Marcgr. Bras. 221, of which the first may be taken as primary.

Type locality (suggested): Surinam.

2. DIDACTYLUS. p. 35.

Cholepus.

First Linnaean reference: Syst. Nat. (6) p. 3.

One reference only: Seba, Thes. i. t. 34.

Type locality (suggested): Surinam.

Genus 8. MYRMECOPHAGA. p. 35.

Three species. Type by elimination: *M. tridactyla*, *M. didactyla* having been taken out as *Cyclopes* and *M. tetradactyla* as *Tamandua*.

Species:

1. DIDACTYLA. p. 35.

Cyclopes.

Based on specimen. Fuller description Mus. Ad. Frid. p. 8.

No locality, but as an identification is made, through Syst. Nat. (6) p. 8, with Seba, pl. 37. fig. 3, we may take as the

Type locality: Surinam.

2. TRIDACTYLA. p. 35.

Myrmecophaga.

Linnaean reference: Syst. Nat. (6) p. 8, where we find "Ray, Quadr. 241. Marcgr. bras. 225."

Ray's account simply refers to, and is based on, that given by Marcgrave of the *Tamandua guacu*, the Great Anteater, of which he gives a recognizable figure.

The Great Anteater, commonly known as *Myrmecophaga jubata*, should therefore, as pointed out in 1901, be known as *M. tridactyla*.

Type locality: Pernambuco.

See Thos. American Naturalist, xxxv. p. 143, 1901.

3. TETRADACTYLA. p. 35.

Tamandua.

Linnean reference: Syst. Nat. (6) p. 8, which gives "Ray, quadr. 242. Marcgr. bras. 226."

Here, again, as in the last species, Ray simply refers back to Marcgrave, whose animal is the *Tamandua*.

Hence the common name *Tamandua tetradactyla* is correct.

Type locality: Pernambuco.

Genus 9. MANIS. p. 36.

Monotypic. Type, *M. pentadactyla*.

Species:

PENTADACTYLA. p. 36.

Manis.

Linnean reference: Syst. Nat. (6) p. 8, where four quotations are given:—

Bontius, Ind. 60 (1658).

Clus. exot. 347.

Olear. Mus. 8, t. 7. f. 1.

Ray, Quadr. 247.

Of these, Bontius, as being the first quoted, should be taken; and here we find the actual locality mentioned, namely, Tajoan = Tai-wan = Formosa.

On this account the species which has ordinarily borne the name of *M. dalmani* Sund., should be considered as the true *M. pentadactyla* of Linnæus.

Moreover, Linnæus also includes in his synonymy Dalman's paper (Act. Stockh. 1749, p. 265) on a Pangolin from China or Formosa; and as he must have seen the specimen when he gave the name *pentadactyla*, the propriety of the above identification is confirmed.

Type locality: Formosa.

Genus 10. PHOCA. p. 37.

Four species. Type by tautonymy: *Ph. vitulina* ("Phoca seu Vitulus marinus," Gesner).

Species:

1. URSINA. p. 37.

Callorhinus.

Sole reference: Steller, Nov. Comm. Petrop. ii. p. 331 (1751).

The Fur-Seal, commonly known as *Callorhinus ursinus*.

Type locality: Bering Island.

2. LEONINA. p. 37.

Mirounga.

Sole reference: Anson, Itin. p. 100.

Sea-Lion.

Type locality: Juan Fernandez.

3. ROSMARUS. p. 38.

Odobenus.

Linnean quotation: Syst. Nat. (6) p. 6, no. 2 (misprinted 8).

Correctly known as *Odobenus rosmarus* (not *Odobænus*, if Brisson is taken as the founder of the generic name).

Type locality: Northern Atlantic.

4. VITULINA. p. 38.

Phoca.

Linnean reference: Syst. Nat. (6) p. 6, no. 1, which refers again to Fauna Suecica, no. 11 (p. 4).

Common Seal.

Type locality: "in Mari Bothnico et Baltico."

Genus 11. CANIS. p. 38.

Seven species. Type by tautonymy: *Canis familiaris*, among whose synonyms there appears "*Canis* Gesner."

Species:

1. FAMILIARIS. p. 38.

Canis.

Linnean references: Faun. Suec. no. 12; Syst. Nat. (6) p. 5.

Type locality: Sweden (Upsala).

2. LUPUS. p. 39.

Canis.

Linnean references: Faun. Suec. no. 13; Syst. Nat. (6) p. 5.

Type locality: Sweden.

3. HYÆNA. p. 40.

Hyæna.

Linnean reference: Syst. Nat. (6) p. 5, where the single reference is to Kæmpf. Amœn. p. 407, fig. 4 (letterpress on p. 411).

The animal commonly called *Hyæna striata*, but whose proper name is *Hyæna hyæna*.

Type locality: Benná Mts., Laristan, S. Persia. Kæmpfer also mentions a specimen from Isfahan.

4. VULPES. p. 40.

Vulpes.

Linnean reference: Syst. Nat. (6) p. 5, no. 6.

Correct name: *Vulpes vulpes*.

Type locality: Sweden (Upsala).

5. ALOPEX. p. 40.

(Vulpes.)

Linnean reference: Syst. Nat. (6) p. 5, no. 5, where the whole entry is

"*Canis cauda recta extremitate nigra Gmel. Vulpes campestris.*"I cannot identify this animal. It has been supposed to be an individual variety of *V. vulpes*, which Blanford (P. Z. S. 1887, p. 635) proposed should bear the name *V. alopex*.

6. LAGOPUS. p. 40.

Alopex.

Linnean reference: Syst. Nat. (6) p. 5, where *V. alba* and *V. cærulescens* are quoted from Kalm and the 'Fauna Suecica.'

Arctic Fox.

Type locality: Sweden (Lapland).

7. AUREUS. p. 40.

Canis.

No Linnean reference, that to the 6th edition being omitted.

However, the first reference, Kæmpf. Amœn. p. 413, fig. 3, is the one quoted in that edition, p. 5, no. 5.

Jackal.

Type locality: Benná Mts., Laristan, S. Persia.

Genus 12. FELIS. p. 41.

Seven species. Type by tautonymy: *Felis catus* ("Felis" Aldr.).

Species:

1. LEO. p. 41.

Felis.

Linnean reference: Syst. Nat. (6) p. 4, no. 1, where the quotation runs "Leo. Dod. gall. t. 1 & 17." The plate 1 referred to appears to be that in Mém. Acad. Sci. Paris, iii. 1666-1699, p. 1, pl. i., publ. 1733, where there is an account of the dissection of four lions and three lionesses.

No type locality available.

2. TIGRIS. p. 41.

Felis.

Linnean reference: Syst. Nat. (6) p. 4, no. 2, where two quotations are given:—

Ray, Quadr. p. 165; Bont. Jav. p. 53.

Taking the first of these, we find a description which mixes up the Jaguar with the Tiger, but Linné's "Habitat in Asia" may be taken as restricting the name to the Tiger.

Later revisers of the races of Tigers, of whom Fitzinger and Matschie may be specially quoted, have restricted *F. tigris* to India proper, and particularly Bengal.

3. PARDUS. p. 41.

Felis.

Linnean reference: Syst. Nat. (6) p. 4, no. 3, where we find Ray, Quadr. p. 166, and Alp. Aegypt. p. 237.

Ray gives no indication of locality, but passing to Alpinus we find an account of Leopards seen at Cairo and Alexandria alive in captivity. The account is, no doubt, partly based on Hunting Leopards (*Cynelurus*), but, none the less, may be accepted as giving for the

Type locality: Egypt.

It may be here reiterated that Linné's "in Indiis" cannot be taken to mean India in the modern sense, but means hardly more than "from abroad." In this case, he gives a synonymy based on African and Mexican references, and then simply puts "Habitat in Indiis."

4. ONCA. p. 42.

Felis.

First reference: Ray, Quadr. p. 168; and this in turn is based primarily on Marcgrave's account of the Jaguar.

Consequently

Type locality: Pernambuco.

5. PARDALIS. p. 42.

Felis.

Linnean reference: Syst. Nat. (6) p. 4, no. 4, where the only citation is

"Catus pardus, Hernandez, Mex. p. 512."

Ocelot.

Type locality: Mexico.

Linnaeus also saw and described as the same species a living specimen "*in Vivario cliffortiano*," but there is nothing in this description inconsistent with the taking of the Mexican Ocelot as the typical form.

6. CATUS. p. 42.

Felis.

Linnean references: Faun. Suecica, no. 3; Syst. Nat. (6) p. 4, no. 6.

Clearly the "Blotched Tabby" Domestic Cat.

See Pocock, P. Z. S. 1907, p. 149.

Type locality: Upsala.

7. LYNX. p. 43.

Lynx.

Linnean references: Faun. Suecica, no. 4; Syst. Nat. (6) p. 4, no. 7; It. Wgoth. p. 222.

North European Lynx.

Type locality: Wenersborg, S. Sweden. (From the first mention in the Westgotha Resa.)

Genus 13. VIVERRA. p. 43.

Five species.

Type, both by elimination and selection: *V. zibetha*.

Species:

1. ICHNEUMON. p. 43.

Mungos.

Linnean references: Linn. in Hasselq. Itin. p. 191, 1757, and Syst. Nat. (6) p. 6, no. 3.

Common Mongoose.

Type locality: Egypt.

2. MEMPHITIS. p. 44.

(?)

No Linnean reference.

"Ysquepatl, Hern. Mex. 332; Seb. Mus. i. p. 68, pl. xlii. fig. 1; Rai, quadr. p. 181."

It does not seem possible to determine to what animal this name should be applied. Hernandez gives a figure which has a superficial resemblance to a Tayra, but the description of the tail is quite inconsistent with this idea, and is applicable rather to a Skunk or *Bassariscus*. Seba's animal was probably a *Nasua*.

Linneæus himself says in one place that the colour is brown above and yellowish below, and in another that it is white above and variegated black and white below, an inconsistency which justifies one in treating the name as unrecognizable.

3. PUTORIUS. p. 44.

Spilogale.

No Linnean reference.

"Putorius americanus striatus, Catesb. Carol. ii. p. 62."

Alleghenian Spotted Skunk.

Type locality: South Carolina.

See Howell, N. Am. Faun. no. 26, pp. 15-17, 1906.

4. ZIBETHA. p. 44.

Viverra.

No Linnean references, that in the 6th edition, p. 6 (Meles, no. 2), being omitted in the 10th. It quotes "Ray, Quadr. 178; Dod. gall. 155."

General references to Clusius, Ray, Dodart, Hernandez, Olearius, and Beltonius.

From the name *zibetha* we may take the "Animal zibethicum" of Ray, Dodart, Hernandez, and Olearius as the primary reference, and of these we should take the first in Ray, who is also the first quoted in the omitted 6th edition reference.

Turning to Ray we find he quotes the description by Faber in Hernandez, Nov. Hispan. pp. 538, 580, and 581 (also quoted by Linneæus). Taking, again, the first of these we find an animal described which has a ringed tail, and would therefore be an Indian Civet. The illustration does not show the rings properly, but they are sufficiently indicated in the description. All the other references are to the African *V. civetta*.

Type locality (from Faber): Bengal.

5. GENETTA. p. 45.

Genetta.

No Linnean reference.

"Genetta s. Ginetta, Rai, quadr. 201. Bell. itin. 76. Gesn. quadr. 550."

The first reference in Ray being to Spain, that may be taken as the type locality, especially as the basis of the name (Gineta) remains as the Spanish colloquial term for the animal.

Genus 14. MUSTELA. p. 45.

Nine species.

Type by tautonymy: *M. erminea* ("Mustela" Gesner; misquoted *Mustela vulgaris*).

Although in this instance alone of the Gesner quotations of the 'Systema' a second name is attached to the primary one, for which tautonymy is claimed, this proves to be a misquotation by Linnæus, and the correct quotations seem actually to strengthen the case for the Ermine being really the typical tautonymous species. For though Linnæus quotes "*Mustela vulgaris*, Gesner," we find, as a matter of fact, that Gesner* did not put *Mustela vulgaris*, but simply "*Mustela*" in the German edition (that quoted in the 1758 'Systema') and in the Latin one "*Mustela proprie sic dicta*," in contradistinction to his "*Mustelis diversis*," which included the Marten and Polecat.

The Ermine was therefore clearly *the* *Mustela* of both Gesner and Linnæus, and should be treated as the type species.

Species:

1. LUTRIS. p. 45.

Lutra.

No Linnean reference.

Lutra marina, Act. Petrop. 1749, p. 267, *i. e.* Steller, Nov.

Comm. Petrop. ii. p. 367 (1751).

Lutra brasiliensis, Rai, quadr. p. "187" (189).

The primary reference is clearly to Steller, and the type locality Kamtchatka.

2. LUTRA. p. 45.

Lutra.

Linnean reference: Faun. Suecica, no. 10.

European Otter.

Type locality: Upsala.

3. GULO. p. 45.

Gulo.

Linnean reference: Faun. Suecica, no. 6.

Glutton.

"Habitat in alpinis Lapponicis, Dalecarlicis, sylvisque vastissimis."

Taking the first place mentioned we have

Type locality: Lapland.

4. BARBARA. p. 46.

Tayra.

Tayra, by description.

"Habitat in Brasilia, M. Ac. Holmens."

* The pagination of Gesner quoted by Linnæus is somewhat confusing. While, in the majority of cases (*e. g.*, the *Putorius*), the pages are quoted from the 1620 Latin edition, the "*Martes*" and the "*Mustela vulgaris*" are given as "151" and "149," these pages coming from the German edition of 1606. Their respective numbers in the 2nd Latin edition (1620) are 764 and 752, and in the original edition (1551) 865 and 851.

5. MARTES. p. 46.

Martes.

Linnean references: Faun. Suecica, no. "3" (7); Syst. Nat. (6) p. 5, no. 2.

Pine Marten.

Type locality: Upsala.

6. PUTORIUS. p. 46.

Mustela.

Linnean references: Faun. Suecica, no. 8; Syst. Nat. (6) p. 5, no. 3.

Polecat.

Type locality: Scania, S. Sweden.

7. FURO. p. 46.

Mustela.

No Linnean reference.

"*Mustela sylvestris*, *Viverra dicta*, Rai, quadr. 199."

Ferret.

"Said to be from Africa."

8. ZIBELLINA. p. 46.

Martes.

No Linnean reference.

"*Mustela s(z)ibellina*, Rai, quadr. p. 201."

Sable.

Type locality: N. Asia.

9. ERMINEA. p. 46.

Mustela.

No Linnean reference.

"*Mustela vulgaris*, Gesn. quadr. 149" (German edition).

Stoat or Ermine.

Type locality: "In unseren Landen" (Germany).

Genus 15. URSUS. p. 47.

Four species. Type by tautonymy: *U. arctos* ("Ursus, Gesner").

Species:

1. ARCTOS. p. 47.

Ursus.

Linnean references: Faun. Suecica, no. 2; Syst. Nat. (6) p. 4, no. 1.

European Brown Bear.

Type locality (ex Faun. Suec.): Northern Sweden.

2. LUSCUS. p. 47.

Gulo.

No Linnean reference.

Ursulus lupo affinis americanus, Edw. av. ii, p. 103, t. 103, 1747.

American Glutton.

Type locality: Hudson's Bay.

3. MELES. p. 48.

Meles.

Linnean references : Faun. Suec. no. 15 ; Syst. Nat. (6) p. 6.

European Badger.

Type locality : Upsala.

4. LOTOR. p. 48.

Procyon.

Linnean references : Syst. Nat. (6) p. 4 ; Act. Stockh. 1747, t. 9. f. 1 (p. 277 & seqq.).

Although in the last-named place Linnæus refers to earlier accounts, yet his description of an actual specimen, whose habit, as mentioned by him (p. 282), of dipping its food in water would have suggested the name *lotor*, should override his synonymy. His statement that the Raccoon is called Ispan by the Swedes in Pennsylvania may be accepted as defining the locality of his animal. Therefore

Type locality : Pennsylvania.

Genus 16. SUS. p. 49.

Four species. Type by tautonymy : *Sus scrofa* ("Sus, Gesn.").

Species :

1. SCROFA. p. 49.

Sus.

Linnean references : Faun. Suec. no. 36 ; Syst. Nat. (6) p. 12.

European Wild Swine.

Type locality : Germany, whence the wild specimens referred to by Linnæus were introduced * into the island of Oeland.

2. PORCUS. p. 50.

Potamochoerus.

Linnean reference : Syst. Nat. (6) p. 12.

Refers to "Rai, quadr. 96," where a further reference is given to Marcgrave's *Porcus guineensis*, whose description is clearly that of the West-African River-Hog.

Type locality : Guinea.

3. TAJACU. p. 50.

Tayassu.

Linnean reference : Syst. Nat. (6) p. 12, no. 3.

Here the only quotation is Ray (Quadr. p. 97), who in turn gives primary importance to Tyson's description (Phil. Trans. Roy. Soc. xiii. p. 359, 1683) of what he calls a Mexican Musk-Hog. We may therefore consider the

Type locality : Mexico.

4. BABYRUSSA. p. 50.

Babirusa.

Linnean reference : Syst. Nat. (6) p. 12, no. 4, where we find two quotations : Ray, Quadr. p. 96, and Seba, Thes. i. p. 80, pl. 1. figs. 2 & 3.

Babirusa.

Type locality (from both Ray and Seba) : "Island of Boero."

* See Lilljeborg, Sver. Rygg. Daggdj. pt. ii. p. 761, 1874.

Genus 17. *DASYPUS*. p. 50.

Six species. Type by tautonymy: *D. novemcinctus* ("Dasypus, Hern.").

Apart from the difficult and doubtful case of *Simia*, this is the only instance in which the use of tautonymy in selecting Linnean types brings out a result contrary to common use.

Linneus placed the name "*Dasypus*" among the synonyms of *D. novemcinctus* alone, and the account in Hernandez from which this name comes is clearly that of one of the group long known as *Tatusia*, more recently as *Tatu*.

The comparatively recent date of the latter change, the extreme ugliness of *Tatu*, which antedates *Tatusia*, and the classical suitability of *Euphractus*, which stands for *sexcinctus* and its allies, will all help to reconcile us to the shifting of *Dasypus* from one group to another.

This shifting is quite unavoidable, if the invaluable principle of tautonymy is to be utilized at all.

Species :

1. *UNICINCTUS*. p. 50. *Cabassous*.

Linnean reference : Syst. Nat. (6) p. 6, no. 4, where the sole reference is to Seba, Mus. i. p. 47, pl. xxx. figs. 3 & 4.

This, or at least fig. 3 (fig. 4 being more doubtful), is clearly the Tatouay or Twelve-banded Armadillo.

No original locality available, but being from Seba, Surinam may be suggested, if *Cabassous* occurs there, which is not as yet certainly known.

2. *TRICINCTUS*. p. 51. *Tolypeutes*.

Linnean reference : Syst. Nat. (6) p. 6, no. 2, where the sole quotation is to Seba, i. p. 62, pl. xxxviii. figs. 2-3.

Seba's animal is a typical Three-banded Armadillo.

Suggested type locality : Surinam.

3. *QUADRICINCTUS*. p. 51. *Tolypeutes*.

Linnean reference : Syst. Nat. (6) p. 6, no. 3, where the single quotation is to "Column. aquat. ii. p. 15. pl. xvi." (1606).

Colonna's animal is a four-banded specimen of *Tolypeutes tricinctus*, of which *D. quadricinctus* is therefore a synonym.

4. *SEXCINCTUS*. p. 51. *Euphractus*.

Linnean references : Mus. Ad. Frid. p. 7 (1754), and Syst. Nat. (6) p. 6, no. 5.

The former takes precedence, as being based on a specimen, whatever the reference to Ray in the latter might lead to.

Six-banded Armadillo.

Type specimen in Stockholm Museum, its locality unknown. But Para specimens agree with it in size, and may be provisionally accepted as typical (cf. P. Z. S. 1903, ii. p. 242).

5. SEPTEMCINCTUS. p. 51. *Dasypus* (= *Tatu* auct.).

Linnean references: Amœn. Acad. i. p. 281, and Syst. Nat.

(6) p. 6, no. 6; but in the latter we are again referred to the former. Thus the synonymy may be excluded and primary importance given to the species described. This is said to be still in the Upsala Museum.

Seven-banded Armadillo.

Type locality not known.

6. NOVEMCINCTUS. p. 51. *Dasypus*.

Linnean references: Mus. Ad. Frid. p. 6, and Syst. Nat. (6)

p. 6, no. 7, but in the latter no further detail is added and we must take the former alone.

Nine-banded Armadillo.

Prof. Einar Lönnberg informs me that the type specimen is still preserved in the Stockholm Museum, and this will need expert examination whenever an attempt is made to work out the present difficult group.

Genus 18. ERINACEUS. p. 52.

Monotypic. Type, *E. europæus*.

Species:

EUROPÆUS. p. 52. *Erinaceus*.

Linnean references to Fauna Suecica, Syst. Nat. (6), and Iter Goth.

Common Hedgehog.

Type locality (from the Gothländska Resa, p. 264): Wamlingbo, S. Gothland Id.

Genus 19. TALPA. p. 52.

Two species. Type by tautonymy: *T. europæa* ("Talpa, Gesn.").

Species:

1. EUROPÆA. p. 52. *Talpa*.

Linnean references to Syst. Nat. (6), Fauna Suecica, and Iter Scanicum.

Common Mole.

Type locality: Upsala*.

2. ASIATICA. p. 53. *Chrysochloris*.

Sole reference: Seba, Mus. i. p. 51, pl. xxxii, figs. 4, 5.

Cape Golden Mole.

Type specimen in British Museum (Lidth de Jeude Coll.), B.M. No. 67.4.12.564 (see P. Z. S. 1892, p. 316).

* The 'Skånska Resa' being later in date than the 'Fauna Suecica,' one cannot justifiably fix a type locality from it when the ordinary Upsalan locality is available from the latter work.

Genus 20. SOREX. p. 53.

Three species. Type by tautonymy: *S. araneus* ("Sorex, Faun. Suec.").

Species:

1. ARANEUS. p. 53. *Sorex.*

Linnean references: Faun. Suec. no. 33; Syst. Nat. (6) p. 10.

Common Shrew.

Type locality: Upsala.

2. CRISTATUS. p. 53. *Condylura.*

Sole reference: P. Kalm.

Type locality: Pennsylvania.

3. AQUATICUS. p. 53. *Scalops.*

Reference to Seba (pl. xxxii. fig. 3), whose figure is of *Talpa europæa*, but the description is clearly that of an American Mole, and was no doubt received from Kalm, who is quoted as authority for the locality.

Common American Mole.

Type locality: Philadelphia.

Genus 21. DIDELPHIS. p. 54.

Five species. Type by selection and elimination: *D. marsupialis*.

Species:

1. MARSUPIALIS. p. 54. *Didelphis.*

Linnean references: Amœn. Acad. i. p. 279; Syst. Nat. (6) p. 10; Mus. Ad. Fr. p. 10.

In the first of these places the primary, and in the others the sole reference is to Seba, Mus. i. p. 64, pl. xxxix., which should be taken as the basis of the name.

Suggested type locality: Surinam.

2. PHILANDER. p. 54. *Caluromys.*

Sole reference: Seba, Mus. i. p. 57, pl. xxxvi. fig. 4.

Philander Opossum.

Type specimen in British Museum, No. 67.4.12.414 (see P.Z.S. 1892, p. 314).

Suggested type locality: Surinam.

3. OPOSSUM. p. 55. *Metachirus.*

Sole reference: Seba, Mus. i. p. 56, pl. xxxvi. figs. 1-2.

Quica Opossum.

Suggested type locality: Surinam.

4. MURINA. p. 55.

Marmosa.

Linnean reference: Amœn. Acad. i. p. 279.—This is an error, the only Opossum referred to being the large *Didelphis marsupialis*.

Second reference: Seba, Mus. i. p. 48, pl. xxxi. figs. 1–2, which must be taken as the basis of the name.

Murine Opossum.

Co-types in British Museum, Nos. 67.4.12.541–542 (see P. Z. S. 1892, p. 314).

Suggested type locality: Surinam.

5. DORSIGERA. p. 55.

Marmosa.

Primary reference to Seba, Mus. i. p. 49, pl. xxxi. fig. 5.

Synonym of *Marmosa murina*.

Type in British Museum, No. 67.4.12.546.

Suggested type locality: Surinam.

Genus 22. RHINOCEROS. p. 56.

Two species. Type by tautonymy: *R. unicornis* ("Rhinceros, Jonst.").

Species:

1. UNICORNIS. p. 56.

Rhinoceros.

Linnean reference: Syst. Nat. (6) p. 11, no. 1.

One-horned Indian Rhinoceros.

From Jonston's 'Quadrupeds' (p. 67, 1657), the first work quoted in the 10th edition, we get the

Type locality: Bengal.

2. BICORNIS. p. 56.

Diceros.

Linnean reference: Syst. Nat. (6) p. 11, no. 2, where no further quotation is given.

Always accepted as the African Two-horned Rhinoceros.

Type locality not determinable, except that the Cape may generally be considered the place whence early specimens were brought. "Habitat in India" may, as usual, be entirely ignored.

Genus 23. HYSTRIX. p. 56.

Five species. Type by tautonymy: *H. cristata* ("Hystrix, Gesn.").

Species:

1. CRISTATA. p. 56.

Hystrix.

Linnean reference: Syst. Nat. (6) p. 9, no. 1, where the first quotation is to Ray (Quadr. p. 206), whence we find

Type locality: Rome.

Common Porcupine.

2. PREHENSILIS. p. 57.

Coendou.

Linnean reference: Syst. Nat. (6) p. 9, no. 2, where the only quotation is to Ray (Quadr. p. 208). There we get an account taken from Marcgrave, whence

Type locality: Pernambuco.

Brazilian Porcupine.

3. DORSATA. p. 57.

Erethizon.

Sole reference: Edw. Aves, p. 52, pl. lii.

Canadian Porcupine.

Type locality: Hudson's Bay.

4. MACROURA. p. 57.

Atherurus.

Linnean reference: Syst. Nat. (6) p. 2, no. 3, where the sole quotation is Seba, Thes. i. p. 84, pl. lii, fig. 1.

Common Brush-tailed Porcupine.

No type locality available.

5. BRACHYURA. p. 57.

Acanthion.

Linnean reference: Syst. Nat. (6) p. 9, no. 4, where the sole quotation is Seba, Thes. i. p. 81, pl. li, fig. 1.

Malay Porcupine.

Type locality: Malacca.

See Lyon, P. U.S. Nat. Mus. xxxii. p. 579, 1907.

Genus 24. LEPUS. p. 57.

Four species. Type by tautonymy: *L. timidus* ("Lepus, Gesn.").

Species:

1. TIMIDUS. p. 57.

Lepus.

Linnean references: Syst. Nat. (6) p. 9, no. 2; Faun. Suec. no. 19.

Variable Hare.

Type locality: Sweden (Upsala).

2. CUNICULUS. p. 58.

Oryctolagus.

Linnean references: Syst. Nat. (6) p. 9, no. 3; Faun. Suec. no. 20.

In the former a reference is again given to the latter.

Clearly based on the Domestic Rabbit ("pupillis rubris").

Later on Linnæus became acquainted with the Wild Rabbit, and stated in the 10th edition:—

"*Habitat in Europa australi.*"

3. CAPENSIS. p. 58.

Lepus.

Common Cape Hare.

Type locality: Cape of Good Hope.

I have considered the question as to whether this might not be

a Rooi-haas (*Pronolagus*), but think the length of the tail too great, while in any case the evidence is insufficient to upset the usually accepted determination.

4. BRASILIENSIS. p. 58.

Sylvilagus.

Linnean reference: Syst. Nat. (6) p. 9, no. 1, where the sole quotation is Ray, p. 205, whose account is taken from Marcgrave.

Hence

Type locality: Pernambuco.

Genus 25. CASTOR. p. 58.

Two species. Type by tautonymy: *C. fiber* ("Castor, Gesn.")

Species:

1. FIBER. p. 58.

Castor.

Linnean references: Faun. Suec. no. 23; Syst. Nat. (6) p. 10, no. 1.

In the latter the only reference is to the former, in which we find Type locality: Lapland.

2. MOSCHATUS. p. 59.

Desmana.

Linnean references: Faun. Suec. no. 24; Syst. Nat. (6) p. 10, no. 2.

Type locality: Russia.

Genus 26. MUS. p. 59.

Sixteen species. Type by tautonymy: *M. musculus* ("Mus, Gesn.")

Species:

1. PORCELLUS. p. 59.

Cavia.

Linnean references: Westgoth. Resa, p. 244 (misprinted 224); Syst. Nat. (6) p. 10, no. 1.

Domesticated Cavy.

2. LEPORINUS. p. 59.

Dasyprocta.

Sole reference: Catesby, Carol. iii. (i. e. ii. Appendix) p. 18, pl. xviii.

An indeterminable species of *Dasyprocta*. Tail too short and size too large for *Myoprocta*.

No type locality available.

3. LEMMUS. p. 59.

Lemmus.

Linnean references to Fauna Suecica and Syst. Nat. (6), as well as to Act. Stockh. 1740, p. 320, pl. vi. figs. 4 & 5, where Linnæus gives an account of the Norway Lemming.

Type locality: Lapland.

4. MARMOTA. p. 60.

Marmota.

Linnean reference: Syst. Nat. (6) p. 10, no. 11, where the sole quotation is Ray, p. 221.

Alpine Marmot.

Type locality: Swiss Alps.

5. MONAX. p. 60.

Marmota.

Sole reference: Edwards, Aves, p. 104, pl. cv.

Woodchuck.

Type locality: Maryland.

6. CRICETUS. p. 60.

Cricetus.

Linnean reference: Syst. Nat. (6) p. 10, no. 10, where the sole quotation is Ray, p. 221.

"In Turingia and Misnia reperitur"—consequently

Type locality: Thuringen.

Common Hamster.

7. TERRESTRIS. p. 61.

Arvicola.

Linnean references: Faun. Suec. no. 29; Syst. Nat. (6) p. 10, no. 5.

Swedish Water-Vole.

Type locality: Upsala.

8. AMPHIBIUS. p. 61.

Arvicola.

Primary reference: Ray, Quadr. p. 217.

Ray's account is quoted from Willughby, and, as both were Englishmen, the animal should be taken as the British Water-Vole.

Type locality: England.

9. RATTUS. p. 61.

Epimys.

Linnean references: Faun. Suec. no. 28; Syst. Nat. (6) p. 10, no. 6.

Black Rat.

Type locality: Sweden (Upsala).

10. MUSCULUS. p. 62.

Mus.

Linnean references: Faun. Suec. no. 31; Syst. Nat. (6) p. 10, no. 8.

House-Mouse.

Type locality: Sweden (Upsala).

11. AVELLANARIUS. p. 62.

Muscardinus.

Linnean reference: Faun. Suec. no. 32.

Dormouse.

Type locality: Sweden (Upsala).

12. SYLVATICUS. p. 62.

Apodemus.

Linnean references : Faun. Suec. no. 30 ; Syst. Nat. (6) p. 10,
no. 7.

Long-tailed Field-Mouse.

Type locality : Sweden (Upsala).

13. STRIATUS. p. 62.

Arvicanthis.

Linnean reference : Mus. Ad. Frid. p. 10.

The punctated white lines described indicate that this mouse is the species usually known as *Arvicanthis pulchellus* Gray. Having been brought in a ship coming from "India," its locality is no doubt that part of W. Africa where such a ship would have touched. Consequently we may consider its

Type locality : Sierra Leone.

14. LONGIPES. p. 62.

Allactaga.

Linnean reference : Mus. Ad. Frid. p. 9.

A five-toed Jerboa, not specifically determinable without examination of the type, if one exists.

15. JACULUS. p. 63.

Jaculus.

References : Linn. in Hasselq. Itin. p. 198 ; Act. Stockh.
1752, p. 123.

Lesser Egyptian Jerboa.

Type locality : Lower Egypt.

16. VOLANS. p. 63.

Sciuropterus.

Primary reference : Ray, Quadr. p. 215, whence we get

Type locality : Virginia.

American Flying-Squirrel.

Other references are given to Seba, who figures a young Petaurista, and Edwards, whose animal was drawn from a living specimen brought from N. America.

Genus 27. SCIURUS. p. 63.

Seven species. Type by tautonymy : *S. vulgaris* ("Sciurus, Gesn.").

Species :

1. VULGARIS. p. 63.

Sciurus.

Linnean references : Faun. Suec. no. 21 ; Syst. Nat. (6) p. 9,
no. 1.

Common Squirrel.

Type locality : Sweden (Upsala).

2. NIGER. p. 64.

Sole reference: Catesby, Carolina, ii. pl. lxxiii.

Southern Fox-Squirrel.

Type locality: Carolina. Considered by Bangs to be Southern South Carolina.

See Bangs, P. Biol. Soc. Wash. x. p. 147, 1896.

3. CINEREUS. p. 64.

Sciurus.

References: Ray, Quadr. p. 215; Catesby, Carolina, ii. p. 74, pl. lxxiv.; Kalm, Itin. ii. p. 409.

Ray's account is short and unimportant, and Catesby's is clearly the primary one. Mr. Bangs has allocated Catesby's animal to the Southern Fox-Squirrel (*Sciurus niger*) in his work on Eastern N.-American Squirrels, and his determination may be accepted.

Type locality: coast region of Carolina.

4. FLAVUS. p. 64.

Linnean and sole reference: Amœn. Acad. i. p. 281.

"Habitat in America."

Indeterminable, except by reference to the type, if one exists.

In the 12th edition, Carthagera is added as the locality, but on what grounds does not appear.

5. GETULUS. p. 64.

Atlantoxerus.

References: Ray, Quadr. p. 216; Edwards, Aves, pl. 198; Seba, Mus. i. p. 76, pl. xlvii. fig. 3.

The first two both refer to the Barbary Squirrel, and the third, which is a Chipmunk, may be ignored.

Type locality: Barbary.

6. STRIATUS. p. 64.

Tamias.

Linnean reference: Mus. Ad. Frid. p. 8, where a quotation is given of Catesby, Carolina, ii. pl. lxxv.

Common Eastern Chipmunk.

Type locality: "Virginia and Carolina."

7. VOLANS. p. 64.

Sciuropterus.

Linnean references: Faun. Suec. no. 22; Syst. Nat. (6) p. 9.

Northern Flying Squirrel, *Sciuropterus russicus*, the name *volans* being already used (from *Mus volans* L.) in the genus.

Type locality: Finland.

Genus 28. CAMELUS. p. 65.

Four species, of which two, *C. dromedarius* and *bactrianus*, have "Camelus" among their synonyms.

Type by tautonymy and elimination: *C. bactrianus* *.

* Cf. 'Opinions of Nomenclature Commissioners,' 1910, p. 37.

Species :

1. DROMEDARIUS. p. 65. *Camelus.*

Linnean reference: Syst. Nat. (6) p. 13, no. 1, where the sole quotation is of Ray, p. 143.

One-humped Camel.

Type locality: "deserts of Libya and Arabia" (Ray).

2. BACTRIANUS. p. 65. *Camelus.*

Linnean reference: Syst. Nat. (6) p. 13, no. 2.

Two-humped Camel.

Type locality: "Bactria."

3. GLAMA. p. 65. *Lama.*

Linnean reference: Syst. Nat. (6) p. 13, no. 3, where the sole quotation is of Ray, p. 145.

Llama.

Type locality: Peru.

4. PACOS. p. 66. *Lama.*

Linnean reference: Syst. Nat. (6) p. 13, no. 4, where Ray (p. 147) is again alone quoted.

Alpaca.

Type locality: Peru.

Genus 29. MOSCHUS. p. 66.

Monotypic.

Species :

1. MOSCHIFERUS. *Moschus.*

Linnean reference: Syst. Nat. (6) p. 13, where Ray is alone quoted.

Type locality (from Linnæus): "Tataria versus Chinam."

Genus 30. CERVUS. p. 66.

Eight species. Type by tautonymy: *C. elaphus* ("Cervus, Gesn").

Species :

1. CAMELOPARDALIS. *Giraffa.*

Linnean reference: Syst. Nat. (6) p. 13, no. 1, where references are given to Bellonius (Obs. ii. p. 119) and Ray, the latter of whom merely quotes the former.

Giraffe.

Type locality: Egypt (seen in captivity at Cairo).

2. *ALCES.* p. 66.*Alces.*

Linnean references: Syst. Nat. (6) p. 13, no. 2; Faun. Suec. no. 37.

Elk.

Type locality: Sweden.

3. *ELAPHUS.* p. 67.*Cervus.*

Linnean references: Faun. Suec. no. 38; Syst. Nat. (6) p. 13, no. 3.

Red Deer.

Type locality: Sweden.

4. *TARANDUS.* p. 67.*Rangifer.*

Linnean references: Faun. Suec. no. 39; Syst. Nat. (6) p. 13, no. 4.

Reindeer.

Type locality: Lapland.

5. *DAMA.* p. 67.*Cervus.*

Linnean references: Faun. Suec. no. 40; Syst. Nat. (6) p. 13, no. 5.

Fallow Deer.

"Habitat in vivariis Regis & Magnatum."

6. *BEZOARTICUS.* p. 67.*Blastocerus.*

References:

Mazama, Hern. mex. p. 324.

Cuguacu-ete, Marcgr. Bras. p. 235; Piso, Bras. p. 98; Ray, Quadr. p. 90.

Linnean diagnosis taken from Marcgrave, whose account should therefore be selected as the primary reference.

Pampas Deer (*Cariacus campestris* auctorum).

Type locality: Pernambuco.

See Lydekker, 'Deer of all Lands,' p. 287.

7. *CAPREOLUS.* p. 68.*Capreolus.*

Linnean references: Faun. Suec. no. 41; Syst. Nat. (6) p. 13, no. 6.

Roe-Deer.

Type locality: Sweden.

8. *GUINEENSIS.* p. 68.

(?)

Linnean reference: Mus. Ad. Frid. i. p. 12.

Hab. Guinea.

Not as yet identified.

Genus 31. CAPRA. p. 68.

Twelve species. Type by tautonymy: *C. hircus* ("Capra, Gesn.").

Species:

1. HIRCUS. p. 68. *Capra.*

Linnean reference: Faun. Suec. no. 42.

Domestic Goat.

2. IBEX. p. 68. *Capra.*

Linnean reference: Syst. Nat. (6) p. 14, no. 6.

Reference to Ray only—p. 77 (misprinted 79).

Swiss Ibex.

Type locality: Swiss Alps—Valais.

3. RUPICAPRA. p. 68. *Rupicapra.*

Linnean reference: Syst. Nat. (6) p. 14, no. 5.

Chamois.

Type locality: Swiss Alps.

4. DEPRESSA. p. 69. (?)

Linnean reference: Syst. Nat. (6) p. 14, no. 2, where a further reference is given to the 3rd and 4th editions of the 'Systema,' but no additional information is there given.

Indeterminable.

5. REVERSA. p. 69. (?)

Linnean reference: Syst. Nat. (6) p. 14, no. 3, where also the 3rd and 4th editions are quoted.

Indeterminable.

6. PYGMEA. p. 69. *Neotragus.*

Linnean reference: Syst. Nat. (6) p. 14, no. 4, where Seba (i. p. 70, pl. xliii. fig. 3) is alone quoted.

Royal Antelope.

Type locality: Guinea.

7. GAZELLA. p. 67. *Oryx.*

Linnean reference: Syst. Nat. (6) p. 14, no. 8, where Ray's *Gazella indica* (p. 79) is alone quoted.

Common Gemsbok.

Locality not defined, but may be taken as S. Africa.

8. CERVICAPRA. p. 69. *Antelope.*

Linnean reference: Syst. Nat. (6) p. 14, no. 7, where there are two quotations—

Gazella africana, Ray, Quadr. p. 79.

Capricerva, Kæmpf. Amœn. p. 398, pl. 401, fig. 1.

Both refer to the Indian Black-Buck.

Type locality: India.

9. DORCAS. p. 69.

Gazella.

Linnean reference : (6) p. 14, no. 9, where the sole quotation is Ray, p. 80.

Common Gazelle.

No definite locality.

10. GRIMMIA. p. 70.

Cephalophus.

Linnean reference : Syst. Nat. (6) p. 14, no. 10, where the only quotation is to Ray's *Capra sylvestris africana grimmii*, which again refers to "Ephem. German. An. 14, Obs. 57," i. e. Grimm, Misc. cur. Acad. Nat. Cur., Decas ii. Ann. iv. p. 131 (1686).

Common Duiker.

Type locality : Cape Town.

11. MAMBRICA. p. 70.

Capra.

Linnean reference : Syst. Nat. (6) p. 14 (no. 11), where the primary quotation is to Ray, p. 81.

A long eared domestic Goat.

Type locality : Syria.

12. AMMON. p. 70.

Ovis.

Sole reference : Gesn. Quadr. p. 155, but the diagnosis and "Habitat in Siberia, Gmelin," indicate another and more essential source of information, which may be traced to J. G. Gmelin, Reise durch Sibirien, i. p. 368 (footnote), 1751.

Siberian Wild-Sheep.

Type locality : Upper Irtisch R., Siberia.

Genus 32. OVIS. p. 70.

Three species. Type by tautonymy : *O. aries* ("Ovis, Gesn.").

Species :

1. ARIES. p. 70.

Ovis.

Linnean references : Faun. Suec. no. 43 ; Syst. Nat. (6) p. 15, no. 1.

Domestic Sheep.

Type locality : Sweden.

2. GUINEENSIS. p. 71.

Ovis.

Linnean reference : Syst. Nat. (6) p. 15, no. 3, where the reference is to Ray, who in turn quotes Marcgrave.

Domestic Sheep of Guinea.

3. STREPSICEROS. p. 71.

Ovis.

Linnean reference : Syst. Nat. (6) p. 15, no. 2, whence Bellonius, Obs. i. p. 20, 1605.

Cretan Domestic Sheep.

Genus 33. Bos. p. 71.

Five species. Type by tautonymy : *B. taurus* ("Bos, Gesn.").

Species :

1. TAURUS. p. 71.

Bos.

Linnean references : Faun. Suec. no. 44 ; Syst. Nat. (6) p. 15, no. 1.

Domestic Ox.

Type locality : Sweden (Upsala).

2. BONASUS. p. 71.

Bison.

Linnean reference : Syst. Nat. (6) p. 15, no. 2, where there is no further reference, so we may take that in the 10th edition to the Bonasus of Ray (p. 71).

European Bison.

No type locality available.

3. BISON. p. 72.

Bison.

Linnean reference : Syst. Nat. (6) p. 15, no. 3, where the sole quotation is the "*Taurus mexicanus*" of Hernandez, Mexico, p. 587.

American Bison.

Type locality : "Mexico."

4. BUBALIS. p. 72.

Bubalus.

Linnean reference : Syst. Nat. (6) p. 15, no. 4, where a diagnosis, but neither further reference nor locality, is given. Passing to the next reference in the 10th edition, we get Ray (p. 72), whose account is based on the domesticated Buffalo. Therefore

Type locality : Italy (Rome).

5. INDICUS. p. 72.

Bos.

Sole reference : Edwards, Aves, iv. p. 200 (1751).

Indian Humped Ox.

Type locality : E. Indies.

Genus 34. EQUUS. p. 73.

Three species. Type by tautonymy : *E. caballus* ("Equus, Gesn.").

Species :

1. CABALLUS. p. 73.

Equus.

Linnean reference : Faun. Suec. no. 34.

Domestic Horse.

2. ASINUS. p. 73.

Equus.

Linnean reference : Faun. Suec. no. 35.

Domestic Ass.

3. ZEBRA. p. 74.

Equus.

Linnean reference : Syst. Nat. (6) p. 11, no. 3, where a diagnosis, but no locality or further reference, is given. Passing to the next reference we have Edwards, Aves, v. pp. 27 & 29, pls. 222 & 223, the first of which is a Mountain Zebra, and the second a Quagga. The first should be taken as typical.

Type locality : Cape of Good Hope.

Genus 35. HIPPOPOTAMUS. p. 74.

Two species. Type by tautonymy : *H. amphibius* ("Hippopotamus, Bell.").

Species :

1. AMPHIBIUS. p. 74.

Hippopotamus.

No Linnean reference, though the species occurs Syst. Nat. (6) p. 11.

Hippopotamus.

Type locality : R. Nile.

2. TERRESTRIS. p. 74.

Tapirus.

Two references : Tapiierete, Marcgr. Bras. p. 229 ; Ray, Quadr. p. 126, where Marcgrave is again quoted.

Brazilian Tapir.

Type locality : Pernambuco.

Genus 36. MONODON. p. 75.

Monotypic.

Species :

1. MONOCEROS. p. 75.

Monodon.

Linnean references : Faun. Suec. no. 263 ; Syst. Nat. (6) p. 39.

Narwhal.

"Habitat in mari atlantico."

Genus 37. BALÆNA. p. 75.

Four species. Type by tautonymy : *B. mysticetus* ("Balæna, Will.").

Species :

1. MYSTICETUS. p. 75.

Balæna.

Linnean references : Faun. Suec. no. 264 ; Syst. Nat. (6) p. 39, no. 1.

In these places the species is called "Grönlands Walfisk" and

"Grönlandswal" respectively, so that the Greenland species of Right Whale may be at once accepted.

Type locality: Greenland seas.

Mr. True, in his 'Nomenclature of the Whalebone Whales'*, comes to the same conclusion, for the same reason, after two pages of discussion of what I venture to consider negligible synonyms.

2. PHYSALUS. p. 75.

Balænoptera.

Linnean references: Faun. Suec. no. 265; Syst. Nat. (6) p. 39, no. 2.

In both these places the reference is to Artedi (Gen. 77, Syn. 107), to which alone validity should be attached.

On reference to Artedi, we find Ray (Syn. Pisc. 9) quoted primarily, who in turn gives an abbreviated account of Martens's "Finfisch." This has been shown by Mr. True to be a Common Rorqual, to which, in agreement with him, I think the name *physalus* should be applied.

Type locality: Spitzbergen seas.

The result is therefore the same as Mr. True's, but the steps are formal, strict, and inevitable, and do not involve any balancing of the importance to be attached to different synonyms.

3. BOOPS. p. 76.

Balænoptera.

Linnean reference: Mus. Ad. Frid. i. p. 51 (misprinted 50).

But this reference is wrong as to page, and the diagnosis is a repetition of that of the succeeding species, *B. musculus*. It may therefore be ignored.

The next reference is to species iii. on p. 107 of Artedi's 'Synonyms,' where in turn Ray's "*Balæna tripinnis* nares habens . . ." is quoted. The latter is based on Sibbald's account of a whale which Mr. True shows to be the same as the last species, *B. physalus*, of which, therefore, *B. boops* is a synonym.

Type locality: Firth of Forth, Scotland.

4. MUSCULUS. p. 76.

Balænoptera.

Linnean reference: Syst. Nat. (6) p. 39, no. 3.

Here we get Artedi, Syn. p. 107, whence come references to Ray (Pisc. p. 17), and, at last, the real basis of all, Sibbald's 'Phalainologia.'

Sibbald's Rorqual.

Type locality: Firth of Forth, Scotland.

* P. U.S. Nat. Mus. xxi. p. 617, 1898.

Genus 38. PHYSETER. p. 76.

Four species nominally, but all prove to be the Sperm Whale, so that the genus is really monotypic.

Species :

1. CATODON. p. 76.

Physeter.

Linnean reference: Syst. Nat. p. 39, no. 1 (of *Catodon*, not *Physeter*), where there is a reference to the "*Catodon fistula in rostro*" of Artedi (Syn. p. 108), by whom in turn Ray and Sibbald are quoted.

Ray's account is abbreviated from that of Sibbald, whose *Balæna minor**, from Kairston, Orkneys, is the real basis of the name.

This animal has been said by some authors to be the Beluga, and by others the Sperm Whale, and after a careful consideration of the question, with the kind and highly opportune assistance of Dr. Einar Lönnberg, I am decidedly of opinion that it was the latter species.

The absence of teeth in the upper jaw is a definite character, to which much weight should be attached; while the fact that females of the Sperm Whale go together in schools would account for the large number (105) stranded at Kairston, and their comparatively small size (24 feet).

As a consequence, the Sperm Whale should bear the name of *Physeter catodon* L., of which the next name would be a synonym.

Type locality: Kairston, Orkneys.

2. MACROCEPHALUS. p. 76.

Physeter.

Linnean references: Faun. Suec. no. 262; Syst. Nat. (6) p. 39, no. 2 (of *Catodon*).

Sperm Whale (*Physeter catodon*, see above).

Type locality: Norwegian seas.

3. MICROPS. p. 76.

(*Physeter.*)

Linnean reference: Syst. Nat. (6) p. 39, no. 1 (of *Physeter*), where Artedi (Syn. 104, Gen. 74) is alone quoted.

4. TURSIO. p. 77.

(*Physeter.*)

Linnean reference: Syst. Nat. (6) p. 39, no. 2 (of *Physeter*), where Artedi (Syn. 104, Gen. 74) is alone quoted.

These two names refer to the mythical "High-finned Cachalot," whose origin no doubt lies in faulty observation of ordinary Cachalots, and they may be considered as synonyms of *Physeter catodon*.

* 'Phalainologia nova.' Caput ii. p. 24.

Genus 39. DELPHINUS. p. 77.

Three species. Type by tautonymy: *D. delphis* ("Delphinus, Bell.").

Species:

1. PHOCÆNA. p. 77. *Phocæna.*

Linnean references: Faun. Suec. no. 266; Syst. Nat. (6) p. 39, no. 1.

Common Porpoise.

Type locality: Swedish seas.

2. DELPHIS. p. 77. *Delphinus.*

Linnean reference: Syst. Nat. (6) p. 39, no. 2, where Artedi (Syn. 105) is alone quoted.

Common Dolphin.

Type locality: "European seas."

3. ORCA. p. 77. *Orcinus.*

Linnean references: Faun. Suec. no. 267; Syst. Nat. (6) p. 39, no. 3.

Common Killer.

Type locality: North Sea.

10. The Duke of Bedford's Zoological Exploration of Eastern Asia.—XIII. On Mammals from the Provinces of Kan-su and Sze-chwan, Western China. By OLDFIELD THOMAS, F.R.S., F.Z.S.

[Received and Read February 7, 1911.]

After making the fine collection from Shan-si and Shen-si, which formed the subject of No. XI. of the present series of papers, the Duke of Bedford's collector, Mr. Malcolm Anderson, paid a visit to Europe and America, and then returned again to China in the autumn of 1909. He there obtained the services of Dr. J. A. C. Smith and Mr. Kingdon Ward, who accompanied him in his further explorations inland.

The party first went up into Southern Shen-si, whence a small collection was sent home, which included the three species whose descriptions were published in the 'Proceedings'*. The other forms then obtained will be referred to in a succeeding paper.

The next collection was made in the mountain region of S.W. Shen-si, but, owing to accidental delays, has reached London later than the succeeding set, which forms the subject of the present paper.

Mr. Anderson's party then proceeded into Kan-su, a province

* P. Z.S. 1910, p. 635. These descriptions, though not so numbered, may be considered to form No. XII. of the present series of papers.

hitherto entirely unrepresented in our National Museum. The collection there made and now described is of the utmost interest and greatly increases our knowledge of the Chinese Fauna.

Then a move was made southward into Western Sze-chwan, the main objective of Mr. Anderson's long journey. For it was in this region that the famous collections of Père David were formed, and authentic specimens of the many species he discovered were vital desiderata for all satisfactory work on Chinese Mammals. Collections were made at and near Ta-tsien-lu, and again with great success on the sacred mountain Omi-san, near Kia-ting-fu.

The result of the party's labours forms, I believe, the finest collection of small mammals that has ever come from China. No less than 16 species and subspecies have had to be described as new*, while authentic specimens have been obtained of nearly all Père David's discoveries.

Special mention may be made of the series of *Neotetracus*, a peculiar Insectivore recently described by Prof. Trouessart, of the black-striped Shrews, no such coloration having been previously described in the Family, of the specimens of *Uropsilus* and *Blarinella*, and of the remarkable Vole *Proedromys bedfordi*, the type of a new genus. In all there are 360 specimens, belonging to 48 species and subspecies.

The collection, as a whole, gives striking evidence of the uniformity of the mammal fauna of China north of an east and west line at about 34° N., corresponding in its western part with the Tsin-ling range of mountains. Specimens from Korea on the east, through Shantung, Shan-si and Shen-si to Kan-su on the west, are all remarkably uniform in character, while there is an abrupt change on passing from Kan-su to the southern side of the range into Sze-chwan. The inhabitants of the former are all "desert-coloured" animals, and of the latter dark animals—no doubt because of the more forested nature of the country.

Zoologists have every reason to be grateful to the Society's President for this fine addition to the available material for working out the Eastern Asiatic Fauna. It forms a worthy supplement to the results that have been already attained by the same means in Japan, Korea, and other parts of China, the whole constituting one of the most magnificent series of collections that has ever been obtained.

Considering again the hardships that had to be undergone, the roughness and wild nature of the country, the unfriendliness of the natives, at whose hands Mr. J. W. Brooke had recently met his death, and the severe climatic conditions, we must extend our admiration to Messrs. Anderson, Smith, and Ward, for the extent of the collection and the excellent condition in which they have succeeded in sending it home.

* The complete account of these new forms appears in this communication, but since the names and preliminary diagnoses were published in the 'Abstract,' No. 90, 1911, these species are distinguished by the names being underlined.—EDITOR.

1. RHINOLOPHUS CORNUTUS PUMILUS K. And.

♂. 2560, 2561, 2563. ♀. 2562, 2564. Kia-ting-fu, S. Szechwan. 1200'.

Apparently indistinguishable from the type, with which Dr. Andersen has compared it.

2. BARBASTELLA DARJELINGENSIS Hodgs.

♂. 2523. Omi-san. 9500'.

A specimen of this rare species was also obtained in Szechwan—at Yin-shin-wan, N.W. of Chong-tu—by Mr. W. N. Fergusson. I can find no difference between these specimens and Hodgson's type from Darjiling.

3. PLECOTUS ARIEL.

Thos. Abstr. P. Z. S. 1911, p. 3 (Feb. 14).

♀. 2343. Ta-tsien-lu, Szechwan. 8400'. B.M. No. 11.2.1.6. Collected 23 June, 1910. *Type*.

Most nearly related to *P. wardi*, but darker.

Size among the largest of the genus. Fur of medium length. General colour dark "broccoli-brown," the ends of the hairs dull drab. Under surface paler drab, the bases of the hairs dark slaty. Muzzle blackish. Proportions of thumbs and hind limbs as in *sacrimontis*.

Skull large, with swollen brain-case and broad interorbital region. Bullæ large, only less than those of the Egyptian species *P. christiei*.

Dimensions of the type, the starred measurements taken in the flesh:—

Forearm 44 mm.

Head and body 53* mm.; tail 57*; ear 43*; third finger, metacarpus 39·5, first phalanx 15·5; thumb (c. u., exclusive of metacarpal) 9·2; lower leg and hind foot (c. u.) 31.

Skull: greatest length 17·2; basi-sinual length 13·2; zygomatic breadth 9; intertemporal constriction 4; mastoid breadth 9·4; front of canine to back of m³ 5·6; greatest horizontal diameter of bullæ 4·6.

Hab. and *Type* as above.

Of the genus *Plecotus*, *P. homochrous* (Nepal) and *puck* (Murree) (doubtfully distinct from each other) stand aside from the rest owing to their narrow brain-case; *auritus* (Europe) has rounder skull, small bullæ, and short thumbs; *christiei** (Egypt) large brain-case and very large bullæ; *wardi* (Ladak and Kashmir) large skull, rather large bullæ, long thumbs, and very pale colour; *sacrimontis* (Japan) large skull, rather small bullæ, and long thumbs; and finally the present species has large rounded skull, large bullæ, long thumbs, and dark colour. No doubt it is most

* Although the name *egyptiacus* is quoted both by Dobson and Trouessart from Is. Geoffroy's paper of 1832, I fail to find anything but "Oreillard d'Égypte" in that paper, and therefore use Gray's name of 1838.

nearly allied to *P. wardi*, but the colours of the two are nearly at the opposite ends of the scale.

4. *MYOTIS ALTARIUM*.

Thos. Abstr. P. Z. S. 1911, p. 3 (Feb. 14).

♂. 2427, 2428, 2429, 2431, 2433. ♀. 2422-2426, 2430, 2432. Omi-san, Sze-chwan. 6000'.

A large species—about the size of *M. bechsteini*—the skull remarkably shortened.

Size large as compared to ordinary small species of *Myotis*. Fur rather long, but thin and poor, at least in summer pelage; hairs of back about 8 mm. in length. General colour above uniform dull brown (paler than "Prout's brown"), the tips of the hairs rather lighter. Under surface little lighter than upper, except that the tips of the hairs are more distinctly lighter. Ears long, nearly as long as in *M. bechsteini*, but rather narrow; inner edge evenly convex, outer slightly concave above, convex in lower half, a strongly developed antitragal lobule at its base, separated by a deep notch. Tragus long, not very sharply pointed, evenly but slightly curved outwards; a well-marked lobule at its outer base. Membranes naked throughout; no fringe on interfemoral. Feet rather above normal size, but not as in "*Leuconoe*"; calcar extending rather more than halfway towards the tip of the tail; a very narrow postcalcareaal lobule.

Skull different in shape from that of ordinary *Myotis*, owing to the shortening of the rostrum, which is broad and evenly narrowed forwards, instead of there being a narrow and nearly parallel-sided anterior portion. This condition is, however, approached in *M. pequinius*. Upper outline without frontal convexity, nearly straight from its highest point near the lambda to a point over the small premolars, then abruptly concave, the short nasal region *retroussée*. Palate unusually vaulted.

Middle upper premolar about half the size of the anterior, both in the tooth-row; and the same is the case with the lower premolars.

Dimensions of the type, the starred measurements taken in the flesh :—

Forearm 45 mm.

Head and body 55*; tail 48*; ear 22*; tragus on inner edge 8; third finger, metacarpus 40, 1st phalanx 13·3; lower leg and foot (c. u.) 29.

Skull: greatest length 15·2, basi-sinual length 12; breadth of brain-case 7·9; front of canine to back of m³ 6·5.

Hab. as above.

Type. Adult female. B.M. No. 11.2.1.9. Original number 2423. Collected 2 August, 1910.

This is a most peculiar species and readily recognizable by its size, long narrow ears, and the unusual shape of its skull, which differs considerably from that of most members of the genus, although another Chinese species, *M. pequinius*, shows an approach to it.

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5. MYOTIS MOUPINENSIS M.-Edw.

♂. 2322. 23 miles S.E. of Ta-tsien-lu, Sze-chwan. 7500'.

Milne-Edwards's *Vespertilio moupinensis* was placed by Dobson as a synonym of *V. muricola* Hodgs., but is readily distinguished by the sharp notch in the outer edge of the ear.

Two specimens of it were also obtained by Mr. W. N. Fergusson at Yin-shin-wan, N.W. of Chong-tu.

6. NEOTETRACUS SINENSIS TROUESS.

♂. 2416. 45 miles S.W. of Ya-chow, W. Sze-chwan.

♂. 2445, 2459 (yg.), 2460 (yg.), 2467, 2468, 2469, 2471, 2480.

♀. 2434 (imm.), 2444, 2446, 2450, 2472. Omi-san. 6000'.

This series of the highly interesting Insectivore, *Neotetracus*, recently described by Prof. Trouessart, forms a most valuable addition to the Museum Collection, and at the same time enables me to increase our knowledge of its distribution and characteristics.

The chief point I have to note is its milk dentition, Mr. Anderson's series including one half-grown and two quite young specimens.

The result of my examination is the following formula, showing both the milk and permanent teeth:—

$$I. \begin{Bmatrix} 1 & . & 2 & . & 3 \\ 1 & . & 2 & . & 0 \\ 1 & . & 2 & . & 3 \\ 1 & . & 2 & . & 3 \end{Bmatrix} \quad C. \begin{Bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{Bmatrix} \quad P. \begin{Bmatrix} 1 & . & 0 & . & 3 & . & 4 \\ & & 0 & . & 3 & . & 4 \\ & & 0 & . & 3 & . & 4 \\ 1 & . & 0 & . & 3 & . & 4 \end{Bmatrix} \quad M. \begin{Bmatrix} 1 & . & 2 & . & 3 \\ & & 1 & . & 2 & . & 3 \end{Bmatrix}$$

Comparing this with the formulæ of other members of the group*, we find that it is almost precisely the same as that of *Hylomys*, agreeing with it even in the absence of a third upper milk incisor, and the presence of the corresponding tooth below. The main difference is in the entire absence, both above and below, in milk and permanent series, of p^2 , this tooth being present in both milk and permanent series of *Hylomys* above, and in the permanent series below.

The proportions of the milk-teeth are not very different from those of *Hylomys*, though di^1 surpasses di^2 to a greater extent.

While the permanent upper carnassial (p^4) is of the usual shape characteristic of the family, its predecessor (dp^4) is quite peculiar in the entire suppression of the small postero-internal cusp and the reduction of the antero-internal, these being in *Hylomys* well developed and approximately similar in position to those on the permanent p^4 . They are also both present in *Gymnura* and *Erinaceus*.

Taking all characters into consideration, I am of opinion that *Neotetracus* is most nearly related to *Hylomys* and is strictly a member of the *Gymnurinae*, without any special leaning towards the *Erinaceinae*.

* Cf. P. Z. S. 1892, p. 505.

"In damp forest; no water.

"Stomach contents, earthworms.

"4 embryos—mammæ 2—2 = 8, another specimen with 5 embryos."—M. P. A.

7. *TALPA LONGIROSTRIS* M.-Edw.

♂. 2538. Omi-san. 9500'.

An old individual from Yung-li-pa, N.W. Sze-chwan, obtained by one of Mr. Styan's collectors, was previously the only specimen of this species in the Museum.

8. *UROPSILUS SORICIPES* M.-Edw.

♂. 2457, 2504, 2520, 2540, 2550, 2554. ♀. 2489, 2527, 2539. Omi-san. 6000'–9500'.

Although, owing to their being occasionally deciduous, the teeth of this animal may have been quite correctly indicated for the type specimen by Prof. Milne-Edwards, the full normal number of teeth would appear to be greater both above and below than he stated. For, above, in front of the larger p^4 there is generally present a minute tooth smaller than any other in the jaw, and in the lower jaw there is a similarly minute tooth immediately following the large anterior incisor. Neither of these is indicated by Milne-Edwards. The full number of the permanent teeth would therefore seem to be

$$I. \frac{3}{2}, C. \frac{1}{1}, P. \frac{3}{3}, M. \frac{3}{3} = \frac{10}{9} \times 2 = 38,$$

the same as in *Dymecodon*. In the milk-dentition, however, there is an interesting difference, as there are three lower milk-premolars in addition to the non-changing p_1 .

Homologising the individual teeth, the full formula would therefore seem to be:—

$$I. \begin{Bmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 0 & 2 & 3 \\ 0 & 2 & 3 \end{Bmatrix} \quad C. \begin{Bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{Bmatrix} \quad P. \begin{Bmatrix} 1 & 0 & 3 & 4 \\ & & 3 & 4 \\ & 2 & 3 & 4 \\ 1 & 0 & 3 & 4 \end{Bmatrix} \quad M. \frac{1 \ 2 \ 3}{1 \ 2 \ 3}$$

This formula may be compared with that of *Dymecodon*, as given in a previous paper of the present series*.

The chief differences in the dentition of the two genera are the minute size (and occasional absence) of p^3 in *Uropsilus*, this tooth in *Dymecodon* being larger than p^1 , the rounder, less carnassial shape of p^4 in *Uropsilus*, and, in the lower jaw, the extremely minute size of the posterior of the two incisors (i_3) and a considerable superiority in size of p_3 over p_1 , these teeth being subequal in *Dymecodon*.

This interesting Insectivore had not been previously represented in the British Museum Collection.

* P. Z. S. 1908, p. 51 (footnote).

9. *Sorex cylindrica* M.-Edw.

♂. 2507, 2547. ♀. 2548, 2555. Omi-san. 9500'.

These Shrews seemed on arrival to represent a totally new form of the group, for they are conspicuously marked with a deep black line running down the centre of the back, a coloration hitherto unrecorded in the family.

But after a personal examination, kindly facilitated by Prof. Trouessart, of the species described under the above name by Milne-Edwards, I have come to the conclusion that Mr. Anderson's specimens are referable to that animal, although its describer made no mention of the dorsal line. Probably the type was skinned out of spirit, and was already discoloured when he described it.

The skull agrees exactly in size and dental characters with that of the type.

10. *Sorex bedfordi* E.

Thos. Abstr. P. Z. S. 1911, p. 3 (Feb 14).

♂. 2323, 2337. 23 miles S.E. of Ta-t sien-lu, W. Sze-chwan.

♂. 2359, 2374, 2391. Ta-t sien-lu. 9000'.

♂. 2441, 2475, 2490, 2506, 2521, 2541. ♀. 2496, 2497, 2500, 2522, 2524, 2532, 2542, 2549. Omi-san. 6000'-9000'.

A smaller species with a dorsal stripe.

Size decidedly smaller than in *S. cylindrica*, to which it perhaps bears the relationship that *S. minutus* does to *S. araneus*. Fur soft and fine; hairs of back about 4.2-4.4 mm. in length. General colour above brown, something between "bistre" and "Prout's brown"; scarcely or not lighter below. Back with an indistinct dorsal stripe, like that of *S. cylindrica*, but usually less distinct, sometimes only discernible as a faint darker median wash often broken over the shoulders; in one instance, however (No. 2532), it is as strongly black as in the larger species. Hands and feet pale brown. Tail dark brown above and terminally below, lighter proximally below.

Skull rather smaller than that of *S. araneus*. Three anterior unicuspid equal; two posterior smaller and subequal, the posterior commonly the larger.

Dimensions of the type:—

Head and body 55 mm.; tail 55; hind foot 13.

Skull: condylo-basal length 17.4, greatest breadth 8.4, upper tooth-series 7.4; front of p⁴ to back of m² 3.5.

Hab. as above. Type from Omi-san, 9500'.

Type. Adult male. B.M. No. 11.2.1.41. Original number 2541. Collected 19 August, 1910.

The characteristic striping of this Shrew is not normally so well marked as in *S. cylindrica*, but it is quite sufficiently evident in all the specimens to afford a ready means of distinguishing the species from any of its allies.

I have named this very pretty little species in honour of the Duchess of Bedford, whose interest in zoology is well known.

11. *SOREX WARDI*.

Thos. Abstr. P. Z. S. 1911, p. 3 (Feb. 14).

♂. 2230. Tau-chow, Kan-su. 9000'. 25 March, 1910. B.M. No. 11.2.1.46. *Type*.

Like *S. bedfordiae*, but paler and with smaller brain-case.

Essential characters as in *S. bedfordiae*. Hairs of back 5.6 mm. in length. Colour paler, the general colour of the body nearly approaching "drab," and the tips of the hairs of the under surface drabby white, markedly contrasting with their slaty bases; a line of demarcation perceptible on sides. Dark dorsal streak well marked, more so than in average *S. bedfordiae*. Hands, feet, and underside of tail brownish white, the tail much more sharply bicolor than in *bedfordiae*.

Skull with the brain-case much smaller, and, especially, lower than in *S. bedfordiae*, its length 4.5 mm. as compared with about 5.5 in average specimens of that animal. Unicuspid subequal throughout, the fourth slightly the smallest. Dental pigmentation moderate.

Dimensions of the type:—

Head and body 53 mm.; tail 49; hind foot 12; ear 8.

Skull: condylo-basal length 17, greatest breadth 8.2; upper tooth-series 7.4; front of p^1 to back of m^2 3.7.

Hab. and *Type* as above.

The paler colour, slightly shorter skull-length, and smaller and much lower brain-case will readily distinguish this Kan-su striped Shrew from its Sze-chwan ally.

I have named it in honour of Mr. F. Kingdon Ward, one of Mr. Anderson's assistants during the expedition.

12. *SORICULUS MACRURUS* Blanford.

♂. 2493. ♀. 2503. Omi-san. 9500'.

Agrees closely with Blanford's type from Darjiling.

13. *SORICULUS SACRATUS*.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♂. 2442, 2451, 2476. ♀. 2452, 2477, 2485. Omi-san. 6000'.

A small species allied to *S. caudatus*; tail rather shorter than head and body.

Size smaller than in any described species. Form light and delicate. Fur fine, velvety; hairs of back about 4.5 mm. in length. General colour near "slate-grey," varying in some specimens towards brown. Under surface paler, glossy "smoke-grey," varying towards "broccoli-brown." Hands and feet pale brown. Tail a little shorter than the head and body, about as in *S. caudatus*, brown above, glossy whitish below.

Skull markedly smaller than that of *S. caudatus*, especially in the size of the brain-case, the facial part, with the tooth-series, being nearly as long as in the allied form. Teeth as in *S. caudatus*; distinguished from those of the last species by the tooth-rows

being further apart anteriorly, so that the median space between the hinder lobe of the first incisors is about equal in breadth to that lobe, markedly narrower in *S. macrurus*.

Dimensions of the type, measured in skin:—

Head and body 60 mm.; tail 54; hind foot (c. u.) 14.

Skull: greatest length (exclusive of incisors) 18.1; basal length 15.7; greatest breadth 9.5; upper tooth-series 8.1; front of p^1 to back of m^2 4.4.

Hab. as above.

Type. Adult ♀. B.M. No. 11.2.1.54. Original number 2485. Collected 10 August, 1910.

This is evidently the local representative of *S. caudatus*, but is readily distinguishable by its much smaller brain-case.

14. CHODSIGOA SMITHII.

Thos. Abstr. P. Z. S. 1911; p. 4 (Feb. 14).

♂. 2349. Ta-tsien-lu. 9000'. 27 June, 1910. B.M. No. 11.2.1.537. *Type.*

Proportions as in *Ch. hypsibia*; size much larger.

Size very large, nearly equaling that of the long-tailed *Ch. salenskii* Kashtch. Fur fine and soft; hairs of back (summer) 3.8 mm. in length. General colour uniform "mouse-grey"; under surface similar in colour, though, owing to the different texture of the hairs, the surface appears more glossy. Muzzle scarcely darker than body. Lateral gland not conspicuous, nearer the hip than the shoulder. Hands and feet brownish white, lighter terminally. Tail rather shorter than head and body, pale brown above, whitish below.

Skull much larger than that of *Ch. hypsibia*, the brain-case flattened, heavily ridged. Proportions of teeth as in that species, their tips as usual lightly pigmented.

Dimensions of the type, an old male:—

Head and body 85 mm.; tail 68; hind foot 18.

Skull: condylo-basal length 22.5, greatest breadth 10.5; upper tooth-series 10.2; front of p^1 to back of m^2 5.3.

Hab. and *Type* as above.

This fine species is conspicuously larger than its ally *Ch. hypsibia* de Wint., with which I synonymize *Ch. berezowski* Kashtch. It is rather smaller than the long-tailed *Ch. salenskii* Kashtch.

I have named it in honour of Dr. J. A. C. Smith, who accompanied Mr. Anderson during the Sze-chwan trip, and assisted largely in making the collection.

15. BLARINELLA QUADRATICAUDA M.-Edw.

♂. 2505, 2556, 2558. ♀. 2557. Omi-san. 9500'.

BLARINELLA, g. n.

More allied to the N.-American *Blarina* than to any of the Old World genera of Shrews. Ears very small, though neither

so rudimentary nor so hair-covered as is the case in *Blarina*; their conch wholly below the surface of the fur. Tail short, but not nearly so short as in *Blarina*. Claws large, the anterior inconspicuously larger than the posterior.

Skull in general build about as in the more delicate species of the subgenus *Cryptotis*, though the rostrum is hardly so high.

Teeth numbering 32, as in *Sorex* and true *Blarina*. Upper unicuspid normally 5, but of such proportions and so slanted that only 3 are as a rule visible in a side view, as in *Cryptotis*. First two large and subequal, third about half their size, its hinder edge level with the front of p^1 ; fourth flattened from before backwards, about half the size of third, and jammed close against it, between it and the minute fifth, which is entirely in the inner half of the tooth-row, close against the large p^1 . Molars square, practically without interspaces posteriorly. Lower teeth about as in *Blarina*, the large incisors with three notches. All teeth heavily pigmented, as in *Blarina*.

Type, *B. quadraticauda* (*Sorex quadraticauda* M.-Edw.).

The discovery that the *Blarina* group is represented in the Old World is a most interesting one and very similar to that of the Sze-chwan *Zapus*, published by M. Pousargues in 1896. The present species was described as a *Sorex* by Milne-Edwards, but when examining the type in Paris some years ago I felt sure it was either *Blarina* or nearly allied to it, and Mr. Anderson's series now enables me to place it with certainty.

Of the four specimens obtained three have five unicuspid, as above described, but in one (No. 2505) the minute fifth is absent on both sides, so that it seemed possible the type was in the same condition, only four unicuspid having been described and figured. A re-examination of it, which I owe to the kindness of Prof. Trouessart, shows that it presents the intermediate condition of having on the right side only 4 unicuspid, the 5th minute one being missing, just as in no. 2505, while on the left this tooth is present. Owing, however, to the accidental loss of the 3rd and 4th unicuspid on this left side, the fact that the minute tooth still present, lying pressed against p^1 , corresponded to the fifth tooth that we now know to be normal to the species, had not been previously observed. There is therefore no doubt whatever as to the specific identity of the present series with Milne-Edwards's animal.

The four groups of short-tailed Shrews may be readily distinguished from each other by the number and relative visibility from outside of the upper unicuspid, as follows:—

5 unicuspid, 4 visible from outside.	<i>Blarina.</i>
5 " 3 " "	<i>Blarinella.</i>
4 " 3 " "	<i>Cryptotis.</i>
3 " 3 " "	<i>Notiosorex.</i>

So entirely are both posterior unicuspid generally hidden in *Blarinella* that the figure of the teeth of *B. (Cryptotis) parva*

given by Merriam in his Monograph* would almost do for it, were it not for the much greater size and posterior extension of the large upper incisor of the Asiatic animal.

16. *CROCIDURA ATTENUATA* M.-Edw.

♂. 2279. ♀. 2278. Wen-hsien Country, Kan-su.

17. *ANOUIROREX SQUAMIPES* M.-Edw.

♂. 2407, 2410, 2412. ♀. 2408, 2409, 2411. 45 miles W. of Ya-chow, Sze-chwan.

♂. 2415, 2417, 2420. ♀. 2418, 2412. 45 miles S.W. of Ya-chow.

♂. 2435, 2436, 2458, 2464, 2470, 2481, 2485, 2487, 2501, 2533. ♀. 2440, 2455, 2465, 2483, 2486, 2488, 2502. Omi-san. 6000'-9500'.

The first-mentioned place would appear to be about 50 miles S.W. of Moupin, the type locality of the species.

18. *VULPES* sp.

♀. 2201. Near Si-Ho-Hsien, S. Kan-su.

Apparently representing *V. filchneri* Matsch. The relationship of this form to the Moupin Fox (*V. hooly* David) is not clear.

19. *MUSTELA RUSSELLIANA*.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♂. 2381, 2382. ♀. 2388, 2389, 2390. Ta-tsien-lu. 12,000'.

A very small species, with the contrasted body-colours and tuftless tail of *M. kathiah*.

Size extremely small, about that of the very smallest known Weasel—the American *M. viscosa* Bangs. Colours of upper and lower surfaces sharply contrasted, as in *M. kathiah* and the Stoats, not as in *M. nivalis*. Upper surface uniform dark brown, rather less rich and more drabby than in *M. kathiah*. No darker markings on face or ears. Under surface a beautiful pinkish buff, turning into white anteriorly on the chin, interramia, and lips. Line of demarcation very sharply marked, running from upper lip to ankle. Arms brown externally, buffy on inner aspect; hands brown, sometimes mottled with white; hind limbs similarly brown externally and buffy on the inner aspect; palms and soles densely hairy. Tail proportionally shorter than in *M. kathiah*, slender, not tufted, uniformly brown, the tip not noticeably darker.

Skull distinguishable from that of all other allied forms by its extremely small size.

Dimensions of the type:—

Head and body 133 mm.; tail 54; hind foot 22; ear 11.

Skull: condylo-basal length 29.3; basal length 27.2; zygomatic breadth 15.2; interorbital breadth 6.2; breadth of brain-case 14;

* N. Am. Fauna, no. 10, pl. iii. fig. 2, 1895.

palatal length 11; front of canine to back of molar 8; p^4 on outer edge 2.9.

A male specimen measures: head and body 138 mm.; tail 54; hind foot 24; carnassial tooth 3.1.

Hab. as above.

Type. Adult female. B.M. No. 11.2.1.86. Original number 2388. Collected 1 July, 1910.

This most beautiful little Weasel competes with the American *M. ricosa* Bangs for the honour of being the smallest existing Carnivore, and is readily distinguishable from any Old World *Mustela* by its small size alone. Its essential coloration is very much as in the much larger *M. kathiah*, of which a local race (*dorsalis*) has been recorded from this region. But the hind foot of that animal measures 30 mm., so that it is evidently quite a distinct species.

The combination *Mustela bedfordi* being already in use, I have given to this striking new species a designation based on the family name of the donor of the present magnificent accession to the National Collection of Mammalia.

20. *TAMIOPS SWINHOEI* M.-Edw.

♂. 2510. Omi-san, Sze-chwan. 9500'.

21. *SCIUROTAMIAS DAVIDIANUS* M.-Edw.

♀. 2277. 40 miles N. of Kai-chow, S. Kan-su.

22. *SCIUROTAMIAS DAVIDIANUS CONSOBRINUS* M.-Edw.

♂. 2320, 2321. ♀. 2316. 23 miles S.E. of Ta-tsien-lu. 7500'.

♂. 2456. Omi-san. 6000'.

The Ta-tsien-lu specimens are not very typical *consobrinus*, but are none of them adult.

23. *MARMOTA ROBUSTA* M.-Edw.

♂. 2270. Old Tau-chow, Kan-su. 9000'.

♀. 2269. Near Tau-chow. 10,000'.

24. *MUS GANSUENSIS* Sat.

♂. 2220, 2221, 2222. 10 miles S. of Tau-chow, Kan-su.

Described as a *Leggada* by Satunin.

25. *EPIMYS CONFUCIANUS LUTICOLOR* Thos.

♂. 2196, 2197, 2199, 2200. ♀. 2198. Near Si-Ho-Hsien, S. Kan-su. 5000'.

♂. 2206, 2219. 60 miles S.E. of Min-chow, Kan-su. 8000'.

♂. 2280, 2286, 2287, 2294, 2295, 2301, 2302, 2309, 2311.

♀. 2281, 2282, 2288, 2310, 2312. Wen-hsien Country, S. Kan-su.

These Kan-su specimens tend to be, as is right, intermediate

between the true *luticolor* of Northern Shen-si and the darker *confucianus* of Sze-chwan. The lighter specimens among them absolutely match some of the typical series, while the darker ones match the lighter individuals of the next following set.

26. *EPIMYS CONFUCIANUS* M.-Edw.

♂. 2313, 2318. ♀. 2314, 2315, 2317, 2319, 23 miles S.E. of Ta-tsien-lu, Sze-chwan.

♂. 2370, 2371, 2372. Ta-tsien-lu. 9000'.

♂. 2405. ♀. 2406. 18 miles E. of Ta-tsien-lu. 5500'.

♀. 2413. 45 miles W. of Ya-chow.

♂. 2443, 2453, 2462, 2463. Omi-san. 6000'.

Pending the arrival of topotypes from Chong-tu, these specimens may be accepted as typical of the true *confucianus*.

27. *EPIMYS LING* Bonh.

♀. 2283, 2289. Wen-hsien Country, Kan-su.

These beautiful ochraceous-buff specimens are quite like the typical series from Kuatun, and are also very similar to an example in the Museum from Sikkim, referred—and perhaps correctly—to *E. jerdoni* Blyth.

But as this latter determination needs revision with better material, I use the Chinese name which happens to be available.

28. *EPIMYS EXCELSIOR*.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14.)

♂. 2360, 2379. ♀. 2380. Ta-tsien-lu, Sze-chwan. 9000'.

♂. 2511, 2526, 2545. Omi-san. 9500'.

General characters of *E. confucianus*, but size larger.

Size larger than in *confucianus*, proportionate length of tail about the same. Fur long and rather coarse, not mixed with spines in any of these specimens; hairs of back about 14 mm. in length, the isolated bristle-hairs attaining 20. General colour of adults coarsely lined cinnamon or clay-colour—not unlike bright-coloured specimens of *E. norvegicus*. Sides clearer and more buffy. Belly pure sharply defined white or creamy white, which extends anteriorly well up over the upper lip. Top of muzzle greyer. Eyes with darker rims. Ears of medium length, greyish brown. Hands white above. Feet white with prominent dark metapodial patches. Tail rather longer than head and body, well-haired and tufted, brown above for about two-thirds its length, white at the end and below; hairs at end 7–8 mm. in length.

Skull differing from that of *confucianus* by its larger size and more delicate build. Nasals long and slender. Interorbital region narrow, its borders sharp-edged, but without definite beads. Brain-case smooth, markedly convex above. Anteorbital plate but little projected. Palatal foramen long. Bullæ small. Molars decidedly larger than in *confucianus*.

Dimensions of the type :—

Head and body 178 mm.; tail 193; hind foot 30; ear 23.

Skull: greatest length 39; basilar length 30.3; zygomatic breadth 18; nasals 15.2×4.3 ; interorbital breadth 4.3; breadth of brain-case 15.6; palatilar length 17; palatal foramina 7.5; upper molar series 6.8.

Hab. of type. Ta-tsien-lu. 9000'.

Type. Adult male, B.M. No. 11.2.1.131. Original number 2379. Collected 30 June, 1910.

The true Rats of the genus *Epimys* are, as usual, some of the most difficult of the collection to make out satisfactorily, owing to their variability in both colour and skull-characters. But it seems clear that this form from the high ground of Ta-tsien-lu and the upper part of Omi-san is a distinct species from the widely spread *E. confucianus*, differing by its greater size, longer skull, and, in fully adult specimens, its paler colour—at least, as compared with the typical dark *E. confucianus* of W. Sze-chwan. It is, of course, a member of the same group of the genus, as is also the next species, which is again a step larger in size than *E. excelsior*.

29. EPIMYS ANDERSONI.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♀. 2478. Omi-san. 6000'. Collected 8 August, 1910. B.M. No. 11.2.1.135. *Type*.

Like *E. confucianus* and *excelsior*, but very much larger and with longer tail.

Size large, though not equaling the giant of this group, *E. edwardsi*. Fur coarse, not spinous; hairs of back about 10 mm. in length. General colour as in *E. excelsior*, a dull-lined clay-colour, more buffy on the sides. Under surface pure sharply defined white. Top of muzzle greyish; sides dark brown, this colour passing backwards and joining the dark eye-rings. Ears of medium length, the proectote dull blackish. Hands white, the dark of the forearms encroaching a little on the metacarpus. Feet brown over the greater part of the metatarsus; toes and hallual border of metatarsus white. Tail very long, fairly well-haired, not conspicuously tufted, brown for its proximal half above, then changing gradually to white; underside wholly white, except just at the base.

Skull in general structure like that of *E. excelsior*, but larger throughout; brain-case rather less convex above.

Dimensions of the type (young adult) :—

Head and body 164 mm.; tail 248; hind foot 37; ear 26.5.

Skull: greatest length 43; basilar length 35; nasals 16.3; breadth of brain-case 17.2; palatilar length 19.8; palatal foramina 8.5; upper molar series 8.2.

The dimensions will at once separate from any of its allies this fine long-tailed Rat, which I have much pleasure in dedicating to its discoverer, Mr. Malcolm Anderson.

30. *APODEMUS SPECIOSUS* PENINSULÆ THOS.

♂. 2202, 2211, 2212, 2213, 2218. 60 miles S.E. of Min-chow, Kan-su. 8000'.

♂. 2227, 2228, 2231, 2232. ♀. 2229. 10 miles S. of Tau-chow, Kan-su. 8000'–9000'.

♂. 2234, 2235, 2237. ♀. 2242. Mts. S.E. of Tau-chow, Kan-su. 10,000'.

♂. 2285, 2305, 2308. Wen-hsien Country, S. Kan-su.

I have already commented on the resemblance of the Shan-si Field-Mouse to that of Korea, and now find that those from Kan-su are again similar in every respect and should undoubtedly be referred to the same subspecies, the animal therefore presenting a noteworthy example of the uniformity of the Fauna of China N. of lat. 34°. As usual, the representative southern form in Sze-chwan is at once distinguishable by its much darker colour.

31. *APODEMUS SPECIOSUS* CHEVRIERI M.-Edw.

2 ♂, 1 ♀. 23 miles S.E. of Ta-tsien-lu, Sze-chwan. 10,000'.

13 ♂, 13 ♀. Ta-tsien-lu. 9000'.

17 ♂, 11 ♀. Omi-san. 6000'–9500'.

32. *APODEMUS AGRARIUS* PALLIDIOR THOS.

♂. 2195. Si-Ho-Hsien, S. Kan-su. 5000'.

♂. 2292. ♀. 2293. Wen-hsien Country, S. Kan-su.

33. *APODEMUS* FERGUSSONI.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♀. 2296. Wen-hsien Country, S. Kan-su.

♀. 2499 (yg.), 2508, 2509 (yg.). Omi-san. 9500'.

Near *A. agrarius*, but without the slightest trace of a dorsal line.

Size and proportions about as in *agrarius*. Fur short and fine, without spines in a May specimen, with them in August examples; hairs of back about 7 mm. in length. General colour above uniform drab-brown, not buffy on sides. Under surface soiled greyish, the bases of the hairs slaty, the tips greyish white; lateral line of demarcation fairly well defined. Back without the slightest trace of a median dorsal line, or even of a median darker dorsal area, some trace of a line being always perceptible in *A. agrarius*. Ears short, coloured like the head. Hands and feet white. Tail rather shorter than head and body, brown above, dull whitish below.

Skull about as in *A. agrarius*.

Dimensions of the type:—

Head and body 107 mm.; tail 98; hind foot 24; ear 15.

Skull: greatest length 27.7; breadth of brain-case 12; upper molar series 4.

Hab. S. Kan-su and Western Sze-chwan.

Type. Adult female, B.M. No. 11.2.1.180. Original number 2296. Collected 8 May, 1910.

This Mouse is readily distinguishable from any of the forms of *agrarius* by the entire absence of a dorsal line, some trace of a line being perceptible in all the available specimens of *A. agrarius ningpoensis*, the form in which it is least developed. Even then I should like to call it a subspecies of *agrarius*, but do not venture to do so without seeing intermediate specimens. The type was obtained at or near the same locality as a well-marked example of *A. agrarius pallidior* (no. 2292), so that in this region at least there seems to be no intergradation.

I have named this animal after the Rev. W. N. Fergusson, from whom the Museum has received four specimens of it, collected at Yin-shin-wan, N.W. of Chong-tu, in 1909.

34. *CRICETULUS ANDERSONI* THOS.

♂. 2215, 2216. ♀. 2217. 60 miles S.E. of Min-chow, Kan-su.
♀. 2225, 2233. 10 miles S. of Tau-chow, Kan-su.

35. *MICROTUS IRENE*.

Thos. Abstr. P. Z. S. 1911, p. 5 (Feb. 14).

♂. 2383, 2386, 2397, 2400, 2404. ♀. 2384, 2385, 2392, 2395, 2396, 2398, 2399, 2401, 2402, 2403. Ta-tsien-lu, W. Sze-chwan. 9000'–12,000'.

Rather larger than *M. arvalis*. M_1 with the same spaces connected as in *Pitymys*.

Fur soft, fine, rather woolly; hairs of back about 9 mm. in length. General colour above brown, under surface slaty washed with greyish white; not sharply defined laterally. Ears projecting beyond the fur, uniformly brown. A small lateral gland present on each side in front of the hips in the males. Hands and feet brownish white; soles with six pads. Tail about twice the length of the foot; brown above, paler on sides and below, not so strongly contrasted as in *M. malcolmi*. Mammæ 2–2 = 8.

Skull of the usual flattened shape, its upper outline straight or even slightly concave over the orbits. Brain-case remarkably small in proportion to the face, smooth, rounded, its ridges and angles scarcely developed; muzzle slender, scarcely bowed downwards; interorbital space unusually narrow, smoothly rounded. Palatal foramina fairly long. Posterior palate normal, the lateral pits not specially deep; mesopterygoid fossa of normal breadth, its anterior border rounded. Bullæ decidedly smaller than in most species of this size.

Incisors of medium strength, considerably bevelled in front. M^3 with pattern very similar to that figured by Blasius in *M. savi* (Faun. Deuts. fig. 221, p. 394). M_1 with only four closed spaces, the fifth and sixth (counting from behind and including the posterior transverse space) opening into each other (as in *Pitymys*)

and also into the seventh, the anterior space, which is curved inwards to form a fifth internal angle, while there are only three external angles; the tooth is thus very like that figured by Büchner in *M. limnophilus* (Mamm. Przewalsk. pl. xviii. fig. 13).

Dimensions of the type:—

Head and body 98 mm.; tail 37; hind foot 18; ear 13.

Skull: condylo-basal length 24·2; basilar length 22; greatest breadth 14·8; nasals 7; interorbital breadth 3·8; breadth of brain-case 12; height of forehead from alveolus of m^2 7; palatilar length 13; palatal foramina 4·8; diagonal diameter of bulla in horizontal plane 6·5; upper molar series (crowns) 5·7.

Hab. as above.

Type. Old female, B.M. No. 11.2.1.195. Original number 2396. Collected 2 July, 1910.

This species is peculiar for the proportionately small size of its brain-case and its narrow interorbital space. From *M. limnophilus* Büchn., which may possibly be allied to it, it is distinguishable by having only three internal angles on m^3 ; the shape of the brain-case would also seem to be more normal in that animal.

36. *MICROTUS MALCOLMI*.

Thos. Abstr. P. Z. S. 1911, p. 5 (Feb. 14).

♂. 2245, 2250, 2251, 2252. ♀. 2246, 2253, 2254, 2255, 2256, 2257. Mts. S.E. of Tau-chow, Kan-su.

A medium-sized Vole with high arched skull, somewhat similar on a smaller scale to that of *M. calamorum* Thos.

Fur soft and fine, of medium length; hairs of back about 9–10 mm. in length*, therefore conspicuously shorter than in *Proedromys*. Colour above lined brown, rather lighter than “bistre”; under surface washed with greyish white, rather markedly contrasted with the upper colour. Ears slightly projecting from the fur, brown. Upper surface of hands and feet dull whitish; soles with six pads. Tail rather more than double the length of the foot, brown above, dull white on sides and below. Mammaræ apparently 2—2=8, but this cannot be made out with certainty.

Skull rather like that of *M. calamorum* on a small scale, though not so strong and heavily ridged. In general shape it is not flattened above, but high, arched above, the nasal profile bowed downwards, the waist narrow and proportionately far forward. Surface everywhere smooth and unridged; squamosal projections scarcely perceptible. Nasals nearly attaining to the level of the premaxillæ behind. Interorbital space narrow, smooth, evenly convex above, not flattened or hollowed mesially. Brain-case smoothly rounded. Palatal foramina of equal breadth throughout, their length exceeding that of $m^1 + m^2$. Posterior palate with very deep lateral pits and unusually narrow mesopterygoid space. Bullæ decidedly larger than the normal.

* In this measurement I always ignore the outstanding tips of the longer hairs, and only measure to the ends of the thick mass of under-fur.

Upper incisors narrow, considerably bevelled laterally.

Molars of normal structure, the pattern of the upper ones, so far as spaces and angles are concerned, essentially as figured by Blasius (p. 379) in *M. arvalis*, though the posterior lobe of m^3 is rather narrower and more elongated. Lower teeth as figured by the same author (p. 366) in *M. ratticeps*, m_1 with a very similar anterior lobe and the same number of closed triangles.

Dimensions of the type:—

Head and body 103 mm.; tail 40; hind foot (c. u.) 17; ear 13.

Skull: condylo-basal length 26.2; basilar length 23.5; greatest breadth 15; nasals 7; interorbital breadth 3.7; breadth of brain-case 12; height of crown from alveolus of m^2 9.2; palatilar length 13.2; diastema 8.3; palatal foramina 5; diagonal length of bulla in horizontal plane 8.2; upper molar series (crowns) 6.1.

Other specimens are smaller, the smallest adult having a condylo-basal length of 23.4, with a hind foot of 16 mm.

Hab. as above.

Type. Adult male, B.M. No. 11.2.1.199. Original number 2245. Collected 4 April, 1910.

I can find no described species to which this Vole can be assigned. Its high skull separates it at once from the great mass of flat-skulled Voles, the shape more recalling that in *M. calamorum*, a species possessing a lateral gland and only five foot-pads. Satunin's three species from Zaidam, W. of Kan-su, are all markedly larger than *M. malcolmi*. Büchner's *M. limnophilus* from the same district is perhaps more closely allied, but would seem to have a paler general colour and a much more roughened and angular skull.

37. *MICROTUS (ANTELIOMYS) CHINENSIS* THOS.

♂. 2328, 2329, 2332, 2338, 2339. ♀. 2326, 2327, 2331, 2333, 2334, 2335, 2340, 2341. 23 miles S.E. of Ta-tsien-lu. 10,000'.

♂. 2512, 2519, 2534, 2543, 2544. ♀. 2491, 2492, 2528, 2551, 2553. Omi-san. 9500'.

This striking Vole was described in 1891* from a specimen found in the stomach of a snake. No other examples have been obtained until now.

The type-locality was Kia-ting-fu, quite close to Omi-san.

38. *MICROTUS (CARYOMYS) EVA*.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♂. 2238, 2239. ♀. 2240, 2241. Mts. S.E. of Tau-chow, Kan-su. 10,000'.

[*CARYOMYS*.]

Like *Eothenomys* in external and general cranial characters, but the teeth with the triangles nearly all closed, instead of being mostly open and connected with each other. Additional postero-

* Ann. Mag. N. H. (6) viii p. 117, 1891.

internal lobes on m^1 and m^2 reduced to minute and scarcely perceptible projections.

Type, *Microtus inez* Thos.

Now that a third species, essentially similar to *M. inez* and *M. nux*, has turned up, I think it advisable to form a special subgenus for the reception of the three. On first describing *M. inez** I purposely delayed making a new subgeneric name until we had evidence as to the existence of other species allied to that peculiar species, but full details were given as to its characteristics.]

Allied to *M. (C.) inez* and *nux*, but with much longer tail.

Form slender, the general proportions, chiefly owing to the unusually long tail, looking very different from those of the allied species. Fur long, soft, and fine; hairs of back nearly 10 mm. in length. General colour above pale brown, greyer than in *nux* and *inez*, the type nearly approaching "broccoli-brown," but other specimens of a warmer tint. Under surface rather variable, greyish slaty, washed with buffy whitish or drab. Ears about as long as the fur, and of about the same colour. Hands and feet white; soles with six pads. Tail remarkably long for a Vole, nearly as long as the body without the head; dark brown above, dull whitish below.

Skull very like that of *M. nux*, except that it is smoother and more lightly built; but even this may be a question of age.

Teeth almost exactly as in *M. nux*; second and third spaces of m^3 , and first and second of m^2 , communicating with each other—all the other triangles closed (except, of course, in the case of m_3).

Dimensions of the type:—

Head and body 88 mm.; tail 50; hind foot 16.5; ear 12.

Skull: condylo-basal length 22.6; basilar length 20.5; greatest breadth 13.5; nasals 6.8; interorbital breadth 4; breadth of brain-case 11.2; palatal length 10.6; palatal foramina 4.1; upper molar series (crowns) 5.

Hab. as above.

Type. Adult male. B.M. No. 11.2.1.223. Original number 2238. Collected 3 April, 1910.

This Vole is at once distinguishable from all its allies by its remarkably long tail.

39. MICROTUS (EOTHENOMYS) MELANOGASTER M.-Edw.

♂. 2284, 2290, 2291, 2297, 2304, 2306, 2307. ♀. 2298, 2299, 2300, 2303. Wen-hsien Country, S. Kan-su.

♂. 2421 (melanoid). 45 miles S.W. of Ya-chow, Sze-chwan. 4000'.

♀. 2461. Omi-san. 6000'.

I fail to find any tangible difference between the Kan-su series and the two specimens from Sze-chwan, which latter are nearly topotypical of the species.

* P. Z. S. 1908, p. 976.

40. *PROEDROMYS BEDFORDI*.

Thos. Abstr. P. Z. S. 1911, p. 4 (Feb. 14).

♀. 2214. 60 miles S.E. of Min-Chow, Kan-su. 8000'.
11 March, 1910. B.M. No. 11.2.1.235. *Type*.*PROEDROMYS* *.

General external form as in *Microtus*. Fur very long. Solepads 6. Mammæ 2—2=8.

Skull heavily built, high, its upper profile strongly curved. Postorbital squamosal projections strongly developed, almost peg-like. Palatal foramina long. Posterior palate normal. Bullæ rather large.

Teeth. Upper incisors heavy, strongly curved, not thrown forward; their front face grooved on its outer third. Lower incisors short posteriorly, ending at the bottom of the notch between the angular and condyloid processes, as in *Antelionomys*. Molars with their enamel spaces all completely separated from each other, the anterior wall of each upper space and posterior of each lower one unusually strongly curved, so as to form in many cases nearly half of a circle. Number of spaces and salient angles as follows:—

$$M. 1 \left\{ \begin{array}{ccc} 5 \text{ spaces, 3 inner and 3 outer angles.} \\ 6 & 5 & 4 \end{array} \right. \quad M. 2 \left\{ \begin{array}{c} 4.2.3 \\ 5.3.3 \end{array} \right. \quad M. 3 \left\{ \begin{array}{c} 4.2.3 \\ 3.3.2 \end{array} \right.$$

M³ very peculiar, consisting of the usual transverse, second and third spaces, and then a circular posterior lobe directed externally, the posterior lobe of this tooth in every other Vole, so far as I am aware, being directed inwards. Anterior space of m₁ forming a simple crescent. M₃ with broad connected spaces across it as usual.

I fail to find any group into which this long-haired Vole can be fitted. Its heavy bowed skull, grooved incisors, peculiar curved walled tooth-spaces, and curious m₃ seem together to distinguish it from any described genus. The grooving of the incisors is possibly an individual character, but the other features of the animal are so marked that it should certainly have a special name.

PROEDROMYS BEDFORDI.

Size medium. General form that of an average Vole, the tail rather more than a third the length of the head and body. Fur excessively long, soft, and fine; hairs of back about 16 mm. in length. General colour above coarsely lined dull brown (darker than "broccoli-crown"), the lower flanks more drabby; under surface slaty drab washed with brownish white. Ears hairy, pale

* *πρόεδρος*, a President. Named in honour of the Society's President, to whose generosity the discovery of this animal is due.

brown. Hands and feet dull white. Tail well-haired, brown above, dull white on sides and below.

Skull and teeth as indicated above.

Dimensions of the type:—

Head and body 103 mm.; tail 41; hind foot 18; ear 13.

Skull: basal length (c.) 26; greatest breadth 16; nasals 7.6×3.2 ; interorbital breadth 3.6; breadth of brain-case 12.2; palatilar length 13.7; diastema 8; palatal foramina 6; upper molar series (crowns) 6.8.

Hab. and *Type* as above.

Interesting and peculiar as this species is in essential characters, it is externally a very ordinary-looking Vole, and indeed scarcely distinguishable from *Microtus malcolmi*, which Mr. Anderson found in some numbers in the same region.

41. MYOSPALAX CANSUS Lyon.

♂. 2263, 2272, 2274. ♀. 2262, 2264, 2265, 2266, 2267, 2268, 2271, 2275, 2276. 10 miles S. of Tau-chow, Kan-su. 8500'.

These are practically topotypes of Dr. Lyon's species, and a study of them shows that the series obtained in Shen-si by Mr. Anderson, and previously referred to *M. cansus**, should be subspecifically separated.

The form may be called:—

MYOSPALAX CANSUS SHENSEIUS.

Thos. Abstr. P. Z. S. 1911, p. 5 (Feb. 14).

General characters as in true *cansus*, but the colour warmer and the tooth-row longer.

Taking only full-coloured specimens into consideration the coloured ends of the hairs above approach "ochraceous-buff," while in *cansus* they average distinctly paler, approximating to "pinkish-buff." As to the tooth-row, among seven adult specimens of true *cansus* (including three well-grown males) the alveolar length of the upper series never exceeds 10.0 mm., while of 16 specimens of *shenseius* some (males) may almost reach 12.0 mm., while nearly all, including females, are 11.0 and upwards. One fully adult specimen only, a female, has the dimension 10.0.

Dr. Lyon's type, a male (although originally called a female), seems to have been unusually large, as its tooth-row measures about that of a female *shenseius*, and therefore more than any of our specimens of the Kan-su form. This would, however, appear to have been an exceptional specimen.

Dimensions of the type:—

Head and body 178 mm.; tail 54; hind foot 30.

Skull: condylo-basal length 45; zygomatic breadth 34; nasals 18×7.7 ; interorbital breadth 6.5; palatilar length 23.5; upper molar series (crowns) 11.4, (alveoli) 11.9.

Hab. Shen-si. *Type* from Yu-lin-fu.

* P. Z. S. 1908, p. 978.

Type. Old male. B.M. No. 9.1.1.216. Original number 1800. Collected 30 April, 1908.

Dr. Allen's "*Myotalpa*" *rufescens** would seem also to have the small teeth of true *M. cansus*, and is geographically closer to the latter.

42. RHIZOMYS VESTITUS M.-Edw.

♀. 2559. Omi-san. 9500'.

The relationship of this form to Gray's *R. sinensis* has not hitherto been satisfactorily defined. It seems, however, to be readily characterized by the much larger size of the skull, the great development of the cranial crests, the length and softness of the fur, and the shortness of the tail. *R. sinensis* probably came from somewhere in South China, perhaps the neighbourhood of Canton.

A third Chinese species may be described as follows:—

RHIZOMYS DAVIDI.

Thos. Abstr. P. Z. S. 1911, p. 5 (Feb. 14).

Colour and character of fur, and length of tail, about as in *R. vestitus*; but size much smaller, nearly as in *R. sinensis*.

Skull slightly larger than that of *R. sinensis*, the male *R. sinensis* about equaling the female *R. davidi*. Crests rather more strongly developed, comparing like sex with like. Nasals more narrowed behind and premaxillary processes proportionately broader, so that, while in *R. sinensis* the combined breadth behind of the two nasals about equals either fronto-premaxillary suture; in *R. davidi* the length of each suture is about twice the distance that separates their nearest points in the middle line. Bullae larger.

Dimensions of the type, measured in skin:—

Head and body (c.) 350 mm.; tail 69; hind foot (wet) 42; ear (wet) 15.

Skull: condylo-basal length 66; upper length from lambda to tip of nasals 53.5; greatest breadth 49.5; nasals 23.2×8.4 ; fronto-premaxillary suture 6.5; interorbital breadth 9.2; greatest occipital breadth 30; palatilar length 35; diastema 20; upper molar series (crowns) 13.3.

An old male skull measures 49 mm. in upper length.

Hab. Kuatun, N.W. Fokien. 3500'.

Type. Old female. B.M. No. 96.12.1.6. Original number 9. Collected December 1898, and presented by J. de La Touche, Esq. Eleven specimens examined.

This fine species, of which the Museum possesses a good series, presented by Messrs. F. W. Styan, J. de La Touche, and C. B. Rickett, is distinguishable from *R. sinensis* by its soft fur, shorter tail, and the above-mentioned cranial characters. From *R. vestitus*, again, by its very much smaller size.

* Bull. Am. Mus. N. H. xxvi. p. 429, 1909.

It is with great pleasure that I name a Chinese animal after Père David, the famous French naturalist and collector, to whom Science owes the discovery of the wonderful series of animals on which Milne-Edwards's 'Recherches Mammifères' was based. Kuatun, the locality of *Rhizomys davidi*, was itself discovered as a collecting-station by Père David, though we owe its more recent exploitation to our own countrymen.

43. *LEPUS SECHUENENSIS* de Wint.

♂. 2258, 2261. ♀. 2259. 30 miles N.W. of Tau-chow, Kan-su. 11,000'.

Although described as from Sze-chwan, it is probable that this species really belongs to the fauna N. and N.W. of the Tsin-ling range. The type was said to be from *North-western* Sze-chwan, and that part of the Province extends into the faunistic region of which Kan-su is a part. No Hare is as yet known from the typical forested area of Western Sze-chwan.

44. *OCHOTONA CANSA* Lyon.

♂. 2236, 2243, 2248, 2249. ♀. 2226, 2244, 2247. Mts. S.E. of Tau-chow, Kan-su.

Tau-chow (Tao-cheo) is the type locality of Dr. Lyon's species.

45. *OCHOTONA TIBETANA*, M.-Edw.

♂. 2325. ♀. 2324. 23 miles S.E. of Ta-tsien-lu, Sze-chwan. 10,000'.

♂. 2387. Ta-tsien-lu. 11,600'.

♂. 2525. Omi-san. 9500'.

These specimens indicate that *O. tibetana* has a wide range of colour-variation, very much as in the allied *O. hodgsoni*.

46. *CAPREOLUS BEDFORDI* Thos.

♂. 2203, 2205, 2207, 2210. ♀. 2204, 2208, 2209. 60 miles S.E. of Min-chow, Kan-su. 8000'.

47. *MOSCHUS SIFANICUS* Büchn.

♀ (immature). 2223. 10 miles S. of Tau-chow, Kan-su. 8500'.

The first example of this striking species that has come to the British Museum.

48. *GAZELLA* sp.

♂ (young). 2260. 30 miles N.W. of Tau-chow, Kan-su. 11,000'.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

November 15th, 1910.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the months of June, July, August, September, and October 1910.

Mr. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., exhibited a spirit-specimen of a young Cairo Spiny Mouse (*Acomys cahirinus*), about twelve hours old, pointing out the advanced state of the young at birth as compared with the common House-Mouse, and remarked that the period of gestation in *Acomys* was eleven days at the most, and that the usual number in a litter was three.

Mr. BONHOTE also remarked on a pair of hybrids between the Bramble-Finch (*Fringilla montifringilla*) and the Chaffinch (*Fringilla caelebs*), which he had deposited at the Gardens and which represented a cross bred for the first time in 1907. He drew attention to the resemblances in the plumage of these birds, and stated that the fertility of the hybrids had not yet been tested.

Mrs. R. HAIG THOMAS, F.Z.S., exhibited a series of skins illustrating an experiment in Pheasant-breeding, and gave an account of the production of *Thaumalea obscura* in the F₂ generation from a cross between *T. amhersti* ♀ and *T. picta* ♂.

Dr. W. NICOLL and Prof. E. A. MINCHIN, M.A., V.P.Z.S., exhibited specimens of two species of Cysticeroids found in the body-

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

cavity of rat-fleas (*Ceratophyllus fasciatus*). One of these species had been found in about four per cent. of the fleas examined and had been shown, by means of feeding experiments carried on by Dr. Nicoll, to be the larval form of the common rat-tapeworm (*Hymenolepis diminuta*). The other species, of which so far only a single example had been found, was probably the larva of *Hymenolepis murina*, a species occurring in rats and mice, and very similar to, possibly identical with, *H. nana*, a dangerous tapeworm of man. The chief interest of the discovery lay in the fact that no intermediate host was previously known for this tapeworm.

The Hon. N. CHARLES ROTHSCHILD, M.A., F.Z.S., exhibited several species of Fleas which were of interest in connection with the spreading of plague by these insects.

Mr. R. I. Pocock, F.L.S., F.Z.S., exhibited a living specimen of the Black Rat (*Mus rattus*) from Sark, which had recently been presented to the Society's Menagerie by Mrs. C. Russell.

Mr. R. I. Pocock also exhibited a female hybrid, bred in the Society's Gardens, between a male Black Lemur (*Lemur macaco*) and a female of the Red-fronted variety of the Fulvous Lemur (*Lemur fulvus rufifrons*), and pointed out that the offspring resembled neither of its parents. It had not inherited the facial fringe of its father nor the white over the eyes and on the forehead of its mother, this area of the head being dark ashy black with a deeper tinted central line, more approaching the colour seen in the Black-fronted variety of the Fulvous Lemur (*L. fulvus nigrifrons*).

Mr. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., read a paper dealing with some experiments he had made on the occurrence of the webfoot character in Pigeons. After referring to Mr. R. Staples Browne's paper on the subject in the P. Z. S. for 1905, in which that gentleman had shown the webfoot to be a simple Mendelian recessive, Mr. Bonhote instanced further cases from the lofts of Mr. F. W. Smalley, F.Z.S., that bore out Mr. Staples Browne's conclusions. Both these gentlemen, however, had been kind enough to give the author birds from their strains, and in the first instance when webbed birds from the different strains were crossed an irregular result—namely, 4 normal and 1 webbed—was obtained. Matings from these birds were continued, and the results were, in almost every case, contrary to Mendelian expectations, normals throwing webs, and webs throwing normals. After discussing various suggestions, Mr. Bonhote came to the conclusion that no really satisfactory explanation was forthcoming. The Mendelian inheritance was apparently there, but dominated and modified by some other agency, and he had been able to find no single explanation which would cover all the results.

Mr. EDWARD DEGEN, F.Z.S., read a paper entitled "Notes on the little-known Lizard *Lacerta jacksoni* Blgr., with special reference to its Cranial Characters," based on a series of specimens recently procured by Mr. R. Kemp in British East Africa.

Mr. G. A. BOULENGER, F.R.S., V.P.Z.S., read a paper "On *Lacerta peloponnesiaca* Bibr.," which contained a new description of this little-known lizard, made from living specimens in the Society's Gardens, with a view to fixing its correct position in the genus *Lacerta*.

A paper entitled "Remarks on two Species of Fishes of the genus *Gobius*, from observations made at Roscoff," was read by Mr. E. G. Boulenger, communicated by Mr. G. A. Boulenger, F.R.S., V.P.Z.S., dealing with the specific distinction of *Gobius minutus* and *G. microps*.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 29th, 1910, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Dr. H. B. FANTHAM, B.A., F.Z.S., and H. HAMMOND SMITH, M.R.C.S., L.R.C.P., F.Z.S.

On a Possible Cause of Pneumo-enteritis in the Red Grouse (*Lagopus scoticus*).

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.

On the Alimentary Tract of certain Birds, and on the Mesenteric Relations of the Intestinal Loops.

3. Prof. A. CABRERA, C.M.Z.S.

On the Specimens of Spotted Hyænas in the British Museum (Natural History).

4. Dr. J. F. GEMMILL, M.A., D.Sc.

The Development of *Solaster endeca* Forbes.

The following communications have been received:—

1. GEORGE P. FARRAN.

Plankton from Christmas Island, Indian Ocean.—I. On Copepoda of the Family Corycæidæ.

2. W. N. F. WOODLAND, F.Z.S.

On the Structure and Function of the Gas-Glands and Retia Mirabilia associated with the Gas-Bladder of some Teleostean Fishes, with notes on the Teleost Pancreas.

3. H. R. HOGG, M.A., F.Z.S.

On some New Zealand Spiders.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

November 22nd, 1910.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

On the night of each Scientific Meeting Motor 'Buses will run direct to the Gardens from Regent's Park Tube Station, starting at 8.5 and 8.20 p.m. The return 'buses after the Meeting will leave the Gardens at 10.15 and 10.35 p.m. These 'buses will be labelled **PRIVATE** and no fare will be charged to Fellows attending the Meetings.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

November 29th, 1910.

Dr. HENRY WOODWARD, F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited, through the kindness of Mons. Pauvvels, a blue variety of the Budgerigar (*Melopsittacus undulatus*), as well as a yellow variety and a normal green specimen.

The two varieties showed distinctly the splitting up of the component coloration, the blue bird lacking all trace of yellow pigment, while in the yellow variety the blue colouring of the normal bird had disappeared.

Dr. WILLIAM NICOLL, of the Lister Institute of Preventive Medicine, gave a demonstration of his method for the collection of Trematodes.

Dr. R. T. LEIPER, F.Z.S., exhibited two photographs and some specimens showing Onchocerciasis in Beef imported from Queensland.

Dr. H. B. FANTHAM, F.Z.S., and Dr. H. HAMMOND SMITH, F.Z.S., contributed a paper "On a Possible Cause of Pneum-enteritis in the Red Grouse (*Lagopus scoticus*)."

The authors recorded that in Grouse-chicks dying of Coccidiosis, many of which showed symptoms of pneumonia, they found Coccidian oöcysts in the bronchioles, bronchi, and trachea. The Coccidian cysts in the bronchioles were probably capable of setting up

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sufficient irritation to account for the pneumonic symptoms. These observations were interesting as showing that the much criticised views of Klein, Tegetmeier, and others on "pneumo-enteritis" as a cause of mortality in Grouse may have some foundation in fact.

Dr. J. F. GEMMILL, M.A., D.Sc., Lecturer on Embryology in the University of Glasgow, gave an account, illustrated by lantern-slides and specimens, of his memoir on "The Development of *Solaster endeca* Forbes," communicated to the Society by Prof. J. Arthur Thomson, F.Z.S.

The author described the ovaries and ova and the processes of spawning, fertilization, segmentation, and gastrulation, and then dealt with the characters of the free-swimming larvæ and the changes related to the metamorphosis. He discussed the development of the internal cavities and of the skeleton, and described the methods he had employed in obtaining and rearing the larvæ.

The memoir, in addition to details of adult anatomy, contained a description of the following points in development:—

Segmentation total equal; blastula by egression; gastrula by invagination; early closure of blastopore; no larval mouth.

Free-swimming larva with three arms and a muscular sucker; attachment by sucker.

Metamorphosis such that while in point of external form the left side of the larva becomes the oral surface of the starfish, in reality the epiderm of the oral surface is derived in great part from that of the anterior part of the early bilateral larva, and conversely the aboral epiderm is derived chiefly from that of the posterior end of the larva.

Archenteron dividing into anterior and posterior vesicles and middle chamber or enteron. Anterior vesicle giving rise to pre-oral, axial, and epigastric cœloms, hydrocœle, dorsal sac, internal oral sinus, and part of external oral sinus. Posterior vesicle giving rise to hypogastric and pharyngeal cœloms, rest of external oral sinus, aboral circular sinus, and genital rachis.

The full set of hydrocœle pouches completed slowly, the series running in the watch-hand direction as seen from the oral side; opening of stone-canal between radii I and II; anus in inter-radius V/VI.

Terminal plates double; rest of aboral plates showing atypical distribution.

A larval nervous system and a statolith-like body in the posterior cœlom.

Mr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, presented a paper "On the Alimentary Tract of certain Birds, and on the Mesenteric Relations of the Intestinal Loops," based on notes he had accumulated relative to the viscera of Birds which had died in the Society's Gardens. The paper dealt

more particularly with species that had not been carefully studied from the point of view of the convolutions of the intestine, and attention was called to a considerable series of Birds.

Mr. OLDFIELD THOMAS, F.R.S., F.Z.S., communicated a paper by Prof. ANGEL CABRERA, C.M.Z.S., "On the Specimens of Spotted Hyænas in the British Museum (Nat. Hist.)," in which he described three apparently new forms.

The next Meeting of the Society for Scientific Business will be held on Tuesday, December 13th, 1910, at half-past Eight o'clock P.M., when the following communications will be made:—

1. ZOOLOGICAL NOMENCLATURE.

Dr. W. E. Hoyle, M.A., F.Z.S., will explain the Report of the International Commission on Zoological Nomenclature presented to the Graz Meeting of the International Zoological Congress, 1910, and will refer in particular to the proposals made for the protection of well-known zoological names.

2. E. S. GOODRICH, M.A., F.R.S., F.Z.S.

On the Segmentation of the Occipital Region of the Head in the Batrachia Urodela.

3. Dr. W. N. F. WOODLAND, F.Z.S.

On the Structure and Function of the Gas-Glands and Retia Mirabilia associated with the Gas-Bladder of some Teleostean Fishes, with notes on the Teleost Pancreas.

4. OLDFIELD THOMAS, F.R.S., F.Z.S.

The Mammals of the Tenth Edition of Linnæus: an Attempt to fix the Types of the Genera and the exact Bases and Localities of the Species.

The following communications have been received :—

1. GEORGE P. FARRAN.

Plankton from Christmas Island, Indian Ocean.—I. On Copepoda of the Family Corycæidæ.

2. H. R. HOGG, M.A., F.Z.S.

On some New Zealand Spiders.

3. DR. F. D. WELCH, F.Z.S.

Observations on different Species of *Hylobates* now or recently living in the Society's Gardens, and a *Symphalangus syndactylus*, with Notes on Skins in the Natural History Museum.

4. R. LYDEKKER.

On *Tragelaphus buxtoni*.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.
December 6th, 1910.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

On the night of each Scientific Meeting Motor 'Buses will run direct to the Gardens from Regent's Park Tube Station, starting at 8.5 and 8.20 p.m. The return 'buses after the Meeting will leave the Gardens at 10.15 and 10.35 p.m. These 'buses will be labelled **PRIVATE** and no fare will be charged to Fellows attending the Meetings.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

December 13th, 1910.

G. A. BOULENGER, Esq., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of November 1910.

Dr. H. HAMMOND SMITH, F.Z.S., exhibited a mounted specimen of a male Red Grouse, from Abington, Lanarkshire, which displayed a curious variety of the ordinary plumage of this species.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited some skins of the Australian Yellow-rumped Finch (*Munia flavi-prymna*). These birds had been kept alive in an outdoor aviary in England, and had developed certain markings tending towards those of another closely allied species, *Munia castaneithorax*. The exhibitor attributed this to the fact that the former species was a desert form of the latter, and when placed in a humid environment tended to revert to the plumage of the latter. He referred to a paper he had published on this subject in the 'Avicultural Magazine,' 1907, p. 195.

Mr. EDWIN S. GOODRICH, M.A., F.R.S., F.Z.S., read a paper "On the Segmentation of the Occipital Region of the Head in the Batrachia Urodela," based on his studies of the development

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of the head region of the Axolotl (*Amblystoma tigrinum*). The head of the Axolotl contained three segments behind the auditory capsule. Three metaotic somites were developed in these segments, of which the first soon disappeared, and the second and third contributed to the formation of the temporal muscle. To the first segment belonged the glossopharyngeal nerve; to the next two the vagus. The occipital condyles were developed between the third and fourth somites. The two hypoglossal roots corresponded to the fourth and fifth metaotic segments, and passed out in front of the first and second vertebræ. In the Amniota all these segments were included in the head. The skull of an Amphibian was thus shorter than that of a Mammal, yet the condyles were homologous in the two animals. The shifting backwards or forwards of the condyles was brought about, not by the inter- or excalation of segments, but by a transposition from one segment to another. The shifting of the condyles was comparable to the transposition of the limbs on the trunk-segments.

MR. OLDFIELD THOMAS, F.R.S., F.Z.S., read a paper entitled "The Mammals of the Tenth Edition of Linnæus: an Attempt to fix the Types of the Genera and the exact Bases and Localities of the Species." It was shown that by the use of tautonymy the types of nearly all the Linnean genera could be definitely fixed; the conclusions arrived at by this means agreeing in most cases with common usage. The type of *Simia*, however, would not be *S. satyrus* but *S. sylvana*, and of *Dasypus* *D. novemcinctus* instead of *D. sexcinctus*, the consequences of which changes were pointed out.

Pygathrix, as represented by the two species *nemæus* and *nigripes*, was shown to be generically distinct from *Presbytis*, so that the latter name still remained available for the ordinary Langurs.

Changes in specific names, due to a complete examination, were shown to be less numerous than might have been expected, while the stability of mammalian nomenclature was much increased by avoiding the danger of what such an examination might lead to.

Type localities, derived from the original authors quoted by Linnæus, were defined for a considerable number of the species.

DR. W. E. HOYLE, M.A., F.Z.S., English Member of the International Commission on Zoological Nomenclature, explained the following Report presented to the Graz Meeting of the International Zoological Congress, and referred in particular to the proposals made for the protection of well-known zoological names.

A discussion followed on the portion relating to the formation of an Official List of most frequently used Zoological Names. The feeling of the Meeting was very strongly in favour of the Inter-

national Congress giving its authority to the formation of a List of Zoological Names, the significance of which should not be altered by application of the rules of the International Code. It was unanimously agreed to accept the action of the Congress if it would adopt this course.

REPORT OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE.

FINANCIAL AID FROM THE SMITHSONIAN INSTITUTION.—Owing to the amount of clerical work connected with the studies conducted by the Commission, it has been found very difficult in the past for the Commission to render its decisions as promptly as desirable. This difficulty has now been overcome by the generous grant of the sum of \$2700 by the Smithsonian Institution; said sum is available at the discretion of the Commission at any time during the three years following the grant.

In addition, the Smithsonian Institution has placed at the disposal of the Commission the sum of \$500 to be used in publishing the "Opinions" rendered by the Commission in its function as a Court of Appeal. An arrangement has been made between the Secretary of the Smithsonian Institution and the Secretary of the Commission, whereby the "Opinions" will be published by the Institution and forwarded to 1100 libraries, to the Members of the International Zoological Congress, and to a limited list of specialists.

OPINIONS RENDERED.—Since October, 1909, the Commission has rendered 23 "Opinions" (Nos. 6–28), which are now in press and which will soon be sent to all Members of the Congress. A number of cases are still before the Commission for study and will be passed upon in the near future. The summaries of Opinions 6–28 are as follows:—

6. *In case of a genus A, Linnaeus, 1758, with two species Ab and Ac.*—When a later author divides the genus *A*, species *Ab* and *Ac*, leaving genus *A* only species *Ab*, and genus *C*, monotypic, with species *Cc*:

The second author is to be construed as having fixed the type of the genus *A*. [See Article 30.]

Vote: Affirmative 14; negative 0; not voting 1.

7. *On the interpretation of the expression "n. g., n. sp." under Article 30 (a).*—The expression "n. g., n. sp.," used in publication of a new genus for which no other species is otherwise designated as genotype, is to be accepted as designation under Article 30 (a).

Vote: Affirmative 8; negative 3; not voting 2; vote both ways 2.

8. *On the retention of ii or i in specific patronymic names, under Article 14 (c) and Article 19.*—Specific patronymics originally published as ending in *ii* (as *schrangkii*, *elbesbornii*) are, according to Article 19, to be retained in their original form, despite the provision of Article 14 (c), which provides that they should have been formed with only one *i*.

Vote: Affirmative 11; negative 1; not voting 2; vote both ways 1.

9. *The use of the name of a composite genus for a component part requiring a name.*—The decision as to whether the name of a composite genus, when made up wholly of older genera, is tenable for a component part requiring a name, depends upon a variety of circumstances. There are circumstances under which such name may be used, others under which it may not be used. (Article 30.)

Vote: Affirmative 13; negative 0; not voting 2.

10. *Designation of genotypes for genera published with identical limits.*—If two genera with the same limits are formed independently by different authors, without designation of genotypes, any subsequent author may designate the genotypes (Art. 30 g); and if the types designated are not specifically identical, the two generic names may (other things being equal) be used for restricted genera containing the types in question. (Article 25.)

Vote: Affirmative 9; negative 4; not voting 2.

11. *The designation of genotypes by Latreille, 1810.*—The “Table des genres avec l’indication de l’espèce qui leur sert de type,” in Latreille’s (1810) ‘*Considérations générales*,’ should be accepted as designation of types of the genera in question. (Article 30.)

Vote: Affirmative 12; negative 1; not voting 2.

12. *Stephanoceros fimbriatus* (Goldfuss, 1820) vs. *Stephanoceros eichhornii* Ehrenberg, 1832.—The generic name *Stephanoceros*, 1832, is to be used in preference to *Coronella*, 1820 (pre-occupied, 1768); the specific name *fimbriatus*, 1820, takes precedence over *eichhornii*, 1832, which is admittedly (Ehrenberg, 1832 b, 125, and 1838 a, 400–401) *fimbriatus*, 1820, renamed. Ehrenberg was right in rejecting *Coronella*, 1820, but in error in rejecting *fimbriatus*, 1820; no reason is apparent for perpetuating his error.

Vote: Affirmative 14; negative 0; not voting 1.

13. *The specific name of the Sand-Crab.*—Catesby’s (1743) pre-Linnæan name *arenarius* is not available under the Code, although “reprinted” in 1771; *quadratus*, 1793, is stated to be pre-occupied; *albicans*, 1802, being the next specific name in the list becomes valid, under the premises submitted.

Vote: Affirmative 12; negative 0; not voting 3.

14. *The type species of Etheostoma Rafinesque, 1819.*—The designation of *E. blennioides* Rafinesque, 1819, as type of *Etheostoma* Rafinesque, 1819, by Agassiz, 1854, is not invalidated by the fact that Agassiz used as basis for his generic diagnosis characters taken from an erroneous specific determination of 1839. Not only does Agassiz distinctly state that “*Eth. blennioides* Raf.” is type of “*Etheostoma* Raf.,” but even if the question of the erroneous identification of *E. blennioides* by Kirtland be taken into consideration, the conclusion must be drawn that this erroneous identification did not exclude the original specimens of *E. blennioides* from being covered by this specific name; on the contrary, the name as used by Kirtland, 1839, still involved the type specimens; removing now the erroneously determined specimens of 1839, which by article 30 e (a) are excluded from consideration in designating the genotype, the original type specimens of 1819 remain and, upon the premises submitted, represent the type of the genus.

Vote: Affirmative 9; negative 4; not voting 2.

15. *Craspedacusta sowerbii* Lankester, 1880, n. g., n. sp., vs. *Limnocoedium victoria* Allman, 1880, n. g., n. sp., a freshwater Medusa.—*Craspedacusta sowerbii* Lankester, 1880, June 17, has clear priority over *Limnocoedium victoria* Allman, 1880, June 24. Presentation of a paper before

a scientific society does not constitute publication in the sense of the Code. The Commission is without authority to sanction usage in contravention of the provisions of the Code.

Vote: Affirmative 15; negative 0.

16. *The status of prebinominal specific names (published prior to 1758) under Art. 30 d.*—In deciding whether a case of absolute tautonymy is present (under Art. 30 d), the citation of a clear prebinominal specific name in synonymy is to be construed as complying with the demands of Art. 30 d. Examples: *Equus caballus* (*Equus* cited in synonymy in the sense of "the horse"), *Alca torda* (*Alca* cited in synonymy in the sense of "the Alca").

Vote: Affirmative 10; negative 2; not voting 3.

17. *Shall the genera of Weber, 1795, be accepted?*—Weber's 'Nomenclator Entomologicus,' 1795, complies with the requirements of Article 25; hence the genera in question are to be accepted, in so far as they individually comply with the conditions of the Code.

Vote: Affirmative 12; negative 1; not voting 2.

18. *The type of Hydrus Schneider, 1799.*—On basis of the premises, *caspius* Schneider, syn. *hydrus* Pallas, is type of *Hydrus* Schneider, Art. 30 d.

Vote: Affirmative 14; negative 0; not voting 1.

19. *Plesiops vs. Pharopteryx.*—From the evidence, it is not clear that this case is one of nomenclatorial rather than zoological nature. So far as the evidence goes, the question as to whether Rüppell was in error in accepting *Plesiops* as identical with *Pharopteryx* must be answered from a systematic point of view. If from our present-day conception of generic limits, Rüppell was correct, no reason is apparent for not accepting his nomenclatorial decision.

Vote: Affirmative 11; negative 1; not voting 3.

20. *Shall the genera of Gronow, 1763, be accepted?*—Gronow, 1763, is binary, though not consistently binominal. Article 25 demands that an author be binary, and Article 2 demands that generic names be uninominal. Under these Articles, Gronow's genera are to be accepted as complying with the conditions prescribed by the Code to render a name available under the Code.

Vote: Affirmative 11; negative 1; not voting 3.

21. *Shall the genera of Klein, 1744, reprinted by Walbaum, 1792, be accepted?*—When Walbaum, 1792, reprinted in condensed form (but did not accept) the genera of Klein, 1744, he did not thereby give to Klein's genera any nomenclatorial status, and Klein's genera do not therefore gain availability under the present Code by reason of being quoted by Walbaum.

Vote: Affirmative 12; negative 0; not voting 3.

22. *Ceraticthys vs. Cliola.*—Whatever Baird's original intentions may have been, he and Girard originally published (1853) *Ceraticthys* as a monotypic genus, describing the genotype (*C. vigilax*) and giving no indication that there were any intentions other than to publish a "n. g., n. sp." Under Article 30 c, *vigilax* is the type of *Ceraticthys*.

Vote: Affirmative 12; negative 0; not voting 3.

23. *Aspro vs. Cheilodipterus, or Ambassis.*—Under the premises given, *Centropomus macrodon* may be taken as type of *Aspro*, 1802, and this generic name suppressed as synonym of *Cheilodipterus*, thus safeguarding *Ambassis*.

Vote: Affirmative 8; negative 1; not voting 6.

24. *Antennarius* Commerson, 1791, and Cuvier, 1817, vs. *Histrio* Fischer, 1813.—*Antennarius* Commerson is an uninominal generic name (Art. 2) of an author who used a binary (Art. 25) (though not binominal) nomenclature. It received nomenclatorial status by virtue of its publication by Lacépède, 1798, and should date from that time instead of from Cuvier, 1817. It is therefore not necessary to suppress it in favour of *Histrio*, 1813.

Vote: Affirmative 12; negative 0; not voting 3.

25. *Damesiella* Tornquist, 1899, vs. *Damesella* Walcott, 1905.—Under Article 36, Recommendations, it is not necessary to reject *Damesella*, 1905, because of the existence of *Damesiella*, 1898 (1899?).

Vote: Affirmative 11; negative 1; not voting 3.

26. *Cypsilurus* vs. *Cypselurus*.—In view of the number of typographical errors in Swainson, 1838 and 1839, the Commission is of the opinion that *Cypsilurus* is an evident typographical error and should be corrected to *Cypselurus*.

Vote: Affirmative 10; negative 1; not voting 4.

27. *Ruppelia* and *Rupellia* vs. *Rüppellia*.—Since a typographical error is evident, *Ruppelia* and *Rupellia* should be corrected to *Rüppellia*.

Vote: Affirmative 9; negative 1; not voting 5.

28. *Shall the 'Nouvelle Classification' of Meigen, 1800, be given precedence over Meigen's 'Versuch,' 1803?*—The generic names contained in Meigen's 'Nouvelle Classification,' 1800, must take precedence over those in his 'Versuch,' 1803, in every case where the former are found valid under the International Code.

Vote: Affirmative 11; negative 0; not voting 4.

OFFICIAL LIST OF MOST FREQUENTLY USED ZOOLOGICAL NAMES.—

There is a desire on the part of some zoologists that certain very commonly used zoological names should be excepted from the application of the *Law of Priority*, and a proposition to this effect has been presented to the Commission from the British Association for the Advancement of Science and the Eastern Branch of the American Society of Zoologists. That this desire is so widespread and so deeply rooted as is assumed by some of our colleagues has not been confirmed by inquiries made by several members of the Commission. Further, an effort made by the Secretary to collect from zoologists the most commonly used and most important generic names has as yet met with such poor success, that the conclusion does not seem entirely unjustified that some of our colleagues who may be in favour of such a list are not as yet sufficiently enthusiastic over the proposition to induce them to demonstrate their desire by placing into the hands of the Commission the data upon which such a list must of necessity be based. Further, there are many colleagues who are known to us to be directly and enthusiastically opposed to such list.

After careful consideration of the subject and of the many difficulties involved, the Commission has decided to propose to the Congress the trial of a proposition which it is hoped

will meet with the approval of both sides of the controversy, namely :—

- (1) The Commission invites all zoologists to send to the Secretary of the Commission, prior to November 1, 1910, a list of 100 zoological generic names which they consider should be studied in connection with the preparation of an "Official List." Each name should be accompanied either by the name of the author of the generic name, or by an indication of the group to which it belongs.
- (2) All systematists are invited to send a separate list of the 50 to 100 generic names in their specialty which they look upon as the most important and most generally used. Each name should be accompanied by the full and complete original bibliographic reference, by the name of the type species, determined according to Art. 30 of the International Rules, and by the name of the order and family to which the genus belongs.
- (3) All zoologists and palæontologists who give courses in General Zoology are invited to supply the Secretary with a list of the text-books used in said courses, so that said books may be indexed for generic names.
- (4) The Commission will alphabetize all the generic names sent in and will endeavour, according to circumstances, to determine which are the 100 to 500 most commonly quoted genera.
- (5) The genera selected will be submitted to specialists in the groups in question, who will be requested to submit opinions on the nomenclatorial status of said names.
- (6) Upon return of the lists from the specialists, the Commission will endeavour to test the names, according to the International Rules, and if feasible will publish a list of the genera in question with their most commonly used names and their correct names.
- (7) If the undertaking is successful, the zoologists of the world will be invited to give to the Commission the benefit of their criticisms not later than July 1, 1912, so that the Commission can restudy the names and submit to the next Congress :
- (8) *An official list of generic names*, with their genotypes, and with the
- (9) Proposition that the Congress adopt said list, and a
- (10) Resolution to the effect that no zoologist shall upon NOMENCLATORIAL grounds change any name in said list unless he first submits to the Commission his reasons for making the change and unless the Commission considers the reasons valid.

The Commission believes that this proposition is feasible, but for the present views it in the light of an experiment, dependent to no small extent upon the question whether a proper amount of co-operation is forthcoming. In this connection the Commission takes the liberty of inviting attention to the fact that the great advances in nomenclature have been made by colleagues who have showed a conviction in their view sufficient to induce them to devote some time to the subject.

AMENDMENTS TO THE "*Règles internationales de la Nomenclature zoologique*."—In its executive sessions the Commission has considered 30 propositions which have been submitted as amendments to the present International Rules. Of these propositions, the Commission unanimously recommends to the Congress the adoption of the following:—

Art. 4. For the word *root*, substitute the word *stem*.

Art. 27 (b). For the word *larva*, substitute the words *any stage in the life-history*.

Art. 35. Insert as a third paragraph the following:—

"Specific names of the same origin and meaning shall be considered homonyms if they are distinguished from each other only by the following differences:

- (a) The use of *ae*, *oe*, and *e*, as *caeruleus*, *coeruleus*, *ceruleus*; *ei*, *i*, and *y*, as *chiropus*, *cheiropus*; *c* and *k*, as *microdon*, *mikrodon*.
- (b) The aspiration or non-aspiration of a consonant, as *oxyrynus*, *oxyrhynchus*.
- (c) The presence or absence of a *c* before *t*, as *autumnalis*, *auctumnalis*.
- (d) By a single or double consonant: *litoralis*, *littoralis*.
- (e) By the endings *-ensis* and *-iensis* to a geographical name, as *timorensis*, *timoriensis*."

Art. 36. Omit from the examples—*Macrodon*, *Microdon*; *caeruleus*, *coeruleus*, *ceruleus*; *silvestris*, *sylvestris*, *silvaticus*, *sylvaticus*; *littoralis*, *litoralis*; *autumnalis*, *auctumnalis*; *dama*, *damma*.

Appendix F. In the English and German texts, substitute the words *transliteration* and *transliterated* for *transcription* and *transcribed*.

Appendix G. In all the three texts, substitute *paragraph* for *rules*, and omit from the heading in French text the words *Règles de la*.

ITALIAN TRANSLATION.—The Commission has voted to issue an official Italian edition of the International Rules.

(Signed) CH. WARDELL STILES,
Secretary of Commission.

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 7th, 1911, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Dr. W. N. F. WOODLAND, F.Z.S.

On the Structure and Function of the Gas-Glands and Retia Mirabilia associated with the Gas-Bladder of some Teleostean Fishes, with notes on the Teleost Pancreas.

2. Prof. J. COSSAR EWART, M.D., F.R.S., F.Z.S.

Skulls of Oxen from the Roman Military Station at Newstead, Melrose.

3. GEORGE P. FARRAN.

Plankton from Christmas Island, Indian Ocean.—I. On Copepoda of the Family Corycæidæ.

4. H. R. HOGG, M.A., F.Z.S.

On some New Zealand Spiders.

The following communications have been received:—

1. Dr. F. D. WELCH, F.Z.S.

Observations on different Gibbons of the Genus *Hylobates* now or recently living in the Society's Gardens, and on a *Symphalangus syndactylus*, with Notes on Skins in the Natural History Museum.

2. R. LYDEKKER.

On *Tragelaphus buxtoni*, an Antelope from Abyssinia.

3. EDWARD G. BOULENGER.

A Contribution to the Study of the Variations of the Common Salamander (*Salamandra maculosa*).

4. G. A. BOULENGER, F.R.S., V.P.Z.S.

On a Collection of Fishes from the Lake Ngami Basin, Bechuanaland.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

December 20th, 1910.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

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ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 7th, 1911.

Prof. E. A. MINCHIN, M.A., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of December 1910.

Dr. C. W. ANDREWS, F.R.S., F.Z.S., exhibited a skull of a Sabre-toothed Tiger (*Smilodon californicus*) from an asphalt deposit in California, and pointed to anatomical characters which tended to prove that the animal used its large canines for stabbing and tearing, not for biting.

The SECRETARY exhibited a mounted specimen of the Platypus, which had been lent for the purpose by Mr. P. St. Michael Podmore, F.Z.S.

Mr. EDWARD GERRARD exhibited the head of a Caribou, shot by Sir John Rogers, K.C.M.G., in British Columbia, which had a distinct third antler over the centre of the orbital arch of the frontal bone. There was a slight burr on a level with the skin, but no pedicle. It had the appearance as if it could be shed in the same manner as the normal antlers.

A very fine Eland head, obtained by Major Gordon on the Bahr-el-Ghazel, and three fine heads of White-tailed Deer were also exhibited, one pair of antlers being abnormal.

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Dr. W. N. F. WOODLAND, F.Z.S., gave an account of a paper on the structure and function of the gas-producing mechanism ("red body") found in connection with the gas-bladders of many Teleostei (Physoclisti and Physostomi). After summarizing some of the principal facts known concerning these subjects, the author discussed various theories already advanced to account for the details of gas-production, and showed that the most satisfactory hypothesis was a combination of the views of Jaeger and of Nusbaum and Reis, supplemented by additional facts and suggestions then advanced in the paper. Among the additional physiological facts adduced were the striking distribution of the capillaries of the *rete mirabile* of the erythrocytolytic granules resulting from the action of Jaeger's toxin on the blood, and the peculiar endothelium of the arterioles towards the proximal pole of the *rete*. Both of these facts, together with the otherwise meaningless conformation of the *rete*, supported the view already advanced by the author that the *rete mirabile duplex* is essentially a device to ensure the diffusion into the arterioles of the toxin poured into the blood by the gas-gland, so that erythrocytolysis shall be well advanced (and therefore the abstraction of oxygen made easy) by the time the arterial blood reaches the gas-"secreting" cells. The author also made suggestions concerning the exact meaning of hæmolysis in connection with the abstraction of oxygen from the blood by the gas-gland cells. The first part of the paper dealt with the comparative morphology of gas-glands.

Prof. J. COSSAR EWART, M.A., F.R.S., F.Z.S., gave an account of his memoir entitled "Skulls of Oxen from the Roman Station at Newstead, Melrose," illustrating his remarks by lantern-slides. He stated that examination of the skulls from Newstead lent support neither to the descent of all European cattle from the Urus (*Bos primigenius*) nor to the descent of all European, Indian, and African breeds from the Asiatic Urus (*B. nomadicus*). He dealt with the evidence to be derived from the maxillæ, the occiput and the temporal fossæ, and stated his conclusions as follows:—

1. That the Celtic Shorthorn (*Bos longifrons*) is probably more intimately related to the Zebu of India (*Bos indicus*) than to the European Urus (*Bos primigenius*).
2. That long premaxillæ are usually correlated with an occiput of the *Bos primigenius* type, while short premaxillæ are usually correlated with an occiput of the *Bos acutifrons* type.
3. That polled black Galloway cattle and polled white "wild" Cadzow cattle are intimately related to the Urus, that flat-polled Aberdeen-Angus cattle probably include amongst their ancestors an ancient Oriental race now represented by, amongst others, a Syrian breed with rudimentary horns, and that round-polled cattle may belong to a still more ancient Oriental race descended from *Bos acutifrons* of the Punjab Siwaliks.

Mr. G. P. FARRAN presented a paper, communicated by Dr. W. T. CALMAN, F.Z.S., on Copepoda of the family Corycæidæ collected by Sir John Murray, K.C.B., F.R.S., and Dr. C. W. Andrews, F.R.S., F.Z.S., at Christmas Island. The collection, though small in bulk, was exceedingly rich in species, and the genus *Corycæus* was especially well represented.

A new genus was proposed and several new species were described and figured.

Mr. H. R. HOGG, M.A., F.Z.S., read a paper on "Some New Zealand Spiders," based on a small collection sent by Prof. Charles Chilton, of Christchurch, New Zealand. Twelve species and eleven genera were represented in the collection, and a new local variety of *Tetragnatha ferox* and four new species were described.

Mr. OLDFIELD THOMAS, F.R.S., F.Z.S., read a paper on Mammals collected in the Provinces of Kan-su and Sze-chwan, Western China, by Mr. Malcolm Anderson, for the Duke of Bedford's Exploration of Eastern Asia. This collection, from a region hitherto almost unrepresented in the British Museum, was perhaps the finest that had ever come from China, at least so far as small mammals were concerned. 47 species were included, represented by 350 specimens, presented, as on previous occasions, to the National Museum by His Grace.

Besides examples of a number of rare and important species not hitherto in the Museum, specimens of the following new forms were included :—

PLECOTUS ARIEL, sp. n.

Allied to *P. wardi*, but much darker in colour.

Forearm 44 mm.; thumb, without metacarpal, 9·2. Skull 17·2 × 9·4.

Hab. Ta-tsien-lu, Sze-chwan. *Type.* Female. No. 2343.

MYOTIS ALTARIUM, sp. n.

Size large. Ears long and rather narrow. Skull with very short muzzle.

Forearm 45 mm.; ear 22. Skull 15·2.

Hab. Omi-san, Sze-chwan. *Type.* Female. No. 2423.

SOREX BEDFORDIÆ, sp. n.

A small dark species, with a blackish line down the back.

Head and body 55 mm.; tail 55; hind foot 13. Skull 17·4 × 8·4.

Hab. Omi-san, Sze-chwan. *Type.* Male. No. 2541.

SOREX WARDI, sp. n.

Paler than *S. bedfordiæ*; tail bicolor; brain-case much smaller.

Head and body 53 mm.; tail 49; hind foot 12. Skull 17 × 8·2.

Hab. Tau-chow, Kansu. *Type.* Male. No. 2230.

SORICULUS SACRATUS, sp. n.

Allied to *S. caudatus*, but brain-case smaller.

Head and body 60 mm.; tail 54; hind foot 14. Skull 18.1×9.5 .

Hab. Omi-san. *Type.* Female. No. 2485.

CHODSIGOA SMITHII, sp. n.

Proportions of tail as in *Ch. hypsibia*, but size much larger.

Head and body 85 mm.; tail 68; hind foot 18. Skull 22.5×10.5 .

Hab. Ta-tsien-lu. *Type.* Male. No. 2349.

MUSTELA RUSSELLIANA, sp. n.

Size excessively small. Colour nearly as in *M. kathiah*. Tail not tufted.

Head and body 133 mm.; tail 54; hind foot 22. Skull 29.3×15.2 .

Hab. Ta-tsien-lu. *Type.* Female. No. 2388.

EPIMYS EXCELSIOR, sp. n.

Allied to *E. confucianus*, but larger. Skull longer and slenderer.

Head and body 178 mm.; tail 193; hind foot 30. Skull 39. Upper molars 6.8.

Hab. Ta-tsien-lu. *Type.* Male. No. 2379.

EPIMYS ANDERSONI, sp. n.

Still larger than *E. excelsior*; tail very long.

Head and body 164 mm.; tail 248; hind foot 37. Skull 43. Molars 8.2.

Hab. Omi-san, Sze-chwan. *Type.* Female. No. 2478.

APODEMUS FERGUSSONI, sp. n.

General characters of *A. agrarius*, but no trace of a dorsal line.

Head and body 107 mm.; tail 98; hind foot 24; ear 15. Skull 27.7.

Hab. Wen-hsien County, S. Kansu. *Type.* Female. No. 2296.

PROEDROMYS BEDFORDI, g. & sp. nn. (Microtinæ).

Incisors grooved. M^3 with posterior lobe cylindrical, external. Fur very long.

Head and body 103 mm.; tail 41; hind foot 18. Skull 26×16 .

Hab. S.E. of Min-chow, Kansu. *Type.* Female. No. 2214.

MICROTUS (CARYOMYS) EVA, sp. n.

(*Caryomys*, subg. n.—Type, *M. inez* Thos.)

Allied to *M. inez*, but tail very much longer.

Head and body 88 mm.; tail 50; hind foot 16.5. Skull 22.6×13.5 .

Hab. Near Tau-chow, Kansu. *Type.* Male. No. 2238.

MICROTUS MALCOLMI, sp. n.

A medium-sized species with high arched skull.

Head and body 103 mm.; tail 40; hind foot 17. Skull 26.2×15 .

Hab. S.E. of Tau-chow, Kansu. *Type.* Male. No. 2245.

MICROTUS IRENE, sp. n.

Skull flattened; brain-case small in proportion to muzzle. M_1 with only four closed spaces.

Head and body 98 mm.; tail 37; hind foot 18. Skull 24.2×14.8 .

Hab. Ta-tsien-lu, Sze-chwan. *Type.* Female. No. 2396.

MYOSPALAX CANSUS SHENSEIUS, subsp. n.

Colour warmer than in true *cansus*. Tooth-row decidedly longer.

Head and body 178 mm.; tail 54; hind foot 30. Upper tooth-row (alveoli) 11.9.

Hab. Yu-lin-fu, Shensi. *Type.* Male. B.M. No. 9.1.1.216.

RHIZOMYS DAVIDI, sp. n.

Soft fur and short tail of *R. vestitus*, but skull scarcely larger than in *R. sinensis*.

Head and body 350 mm.; tail 69; hind foot 42. Skull 66×49.5 .

Hab. Kuatun, Fo-kien. *Type.* Female. B.M. No. 96.12.1.6.

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 21st, 1911, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Dr. H. G. PLIMMER, F.R.S., F.Z.S., Pres.R.M.S.

Report on the Deaths which occurred in the Zoological Gardens during 1910.

2. R. LYDEKKER.

On *Tragelaphus buxtoni*, an Antelope from Abyssinia.

3. EDWARD G. BOULENGER.

A Contribution to the Study of the Variations of the Common Salamander (*Salamandra maculosa*).

4. G. A. BOULENGER, F.R.S., V.P.Z.S.

On a Collection of Fishes from the Lake Ngami Basin,
Bechuanaland.

5. Dr. F. D. WELCH, F.Z.S.

Observations on different Gibbons of the Genus *Hylobates*
now or recently Living in the Society's Gardens, and on a
Symphalangus syndactylus, with Notes on Skins in the Natural
History Museum.

The following communications have been received:—

1. R. LYDEKKER.

- (a) A rare Beaked Whale.
- (b) Age Phases of the Rorqual.

2. Mrs. E. W. SEXTON.

On the Amphipod Genus *Leptocheirus*.

3. F. E. BEDDARD, M.A., F.R.S., F.Z.S.

(a) Contributions to the Anatomy of the Anura.—I. Some
Anatomical Notes upon the Frog *Megalophrys (Leptobrachium)*
fav.

(b) On the Spermatophores in Earthworms of the Genus
Pheretima (=Perichaeta).

4. WILLIAM NICOLL, M.A., D.Sc., M.B.

On Three new Trematodes from Reptiles.

5. G. STEWARDSON BRADY, M.D., LL.D., D.Sc., F.R.S., C.M.Z.S.

Notes on Marine Ostracoda from Madeira.

6. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., and F. W. SMALLEY,
F.Z.S.

On Colour and Colour-pattern Inheritance in Pigeons.

7. P. CHALMERS MITCHELL, M.A., D.Sc., Hon.LL.D., F.R.S.,
F.Z.S.

On Longevity and Relative Viability in Mammals and Birds;
with a Note on the Theory of Longevity.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

February 14th, 1911.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

On the night of each Scientific Meeting Motor 'Buses will run direct to the Gardens from Regent's Park Tube Station, starting at 8.5 and 8.20 p.m. The return 'buses after the Meeting will leave the Gardens at 10.15 and 10.35 p.m. These 'buses will be labelled **PRIVATE** and no fare will be charged to Fellows attending the Meetings.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 21st, 1911.

Dr. A. SMITH WOODWARD, F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of January 1911.

Mr. A. HENEAGE COCKS, F.Z.S., exhibited a series of photographs of the female Brindled Gnu recently born in the Society's Gardens, and gave a brief account of its growth and coloration.

Dr. H. HAMMOND SMITH, M.R.C.S., F.Z.S., exhibited three skins of male Pheasants assuming female plumage, sent to him by Mr. Arthur Gilbey, and some microscopical specimens of the glands prepared by Dr. S. G. Shattock.

Dr. H. G. PLIMMER, F.R.S., F.Z.S., Pathologist to the Society, reported on the Deaths which had occurred in the Zoological Gardens during the past year, and illustrated his remarks with a large series of lantern-slides, prepared from pathological material obtained in the course of his work at the Gardens.

Mr. R. LYDEKKER communicated a short paper on *Tragelaphus buxtoni*, an Antelope obtained by Mr. Ivor Buxton in Abyssinia.

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Mr. E. G. BOULENGER read a paper, communicated by Mr. G. A. BOULENGER, F.R.S., V.P.Z.S., on the varieties of the Spotted Salamander (*Salamandra maculosa*), illustrated by lantern-slides and specimens. One of the principal results of the author's study was to lay greater stress on the disposition of the spots than on their actual form, size, or colour, and to define two principal forms in Central Europe, which had not previously been separated with sufficient precision, notwithstanding their well-marked geographical distribution.

The author further dealt with some of the experiments of Dr. Kammerer, of Vienna, and the conclusions arrived at by him with regard to coloration in relation to environment.

Mr. G. A. BOULENGER, F.R.S., V.P.Z.S., contributed a paper based on a collection of Fishes from the Lake Ngami Basin, Bechuanaland, made by Mr. R. B. Woosnam, F.Z.S.

This paper will appear in the 'Transactions' in due course.

Dr. F. D. WELCH, F.Z.S., communicated a paper on Gibbons of the Genus *Hylobates*, and on a Siamang Gibbon, recently living in the Society's Gardens, with notes on skins in the British Museum (Nat. Hist.).

The next Meeting of the Society for Scientific Business will be held on Tuesday, March 7th, 1911, at half-past Eight o'clock P.M., when the following communications will be made :—

LANTERN EXHIBITIONS :—

- a. Habits of Moose.
- b. Carl Hagenbeck's Tierpark,

1. The Hon. N. CHARLES ROTHSCHILD, M.A., F.Z.S.

Some new Siphonaptera from China.

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.

(a) Contributions to the Anatomy of the Anura.—I. Some Anatomical Notes upon the Frog *Megalophrys* (*Leptobrachium*) *fcc.*

(b) On the Spermatophores in Earthworms of the Genus *Pheretima* (= *Perichæta*),

3. R. LYDEKKER.

- (a) A rare Beaked Whale.
 (b) Age Phases of the Rorqual.

4. P. CHALMERS MITCHELL, M.A., D.Sc., Hon.L.L.D., F.R.S.,
 F.Z.S.

On Longevity and Relative Viability in Mammals and Birds;
 with a Note on the Theory of Longevity.

The following communications have been received :—

1. Mrs. E. W. SEXTON.

On the Amphipod Genus *Leptocheirus*.

2. WILLIAM NICOLL, M.A., D.Sc., M.B.

On Three new Trematodes from Reptiles.

3. G. STEWARDSON BRADY, M.D., LL.D., D.Sc., F.R.S., C.M.Z.S.

Notes on Marine Marine Ostracoda from Madeira.

4. J. LEWIS PONEOTE, M.A., F.L.S., F.Z.S., and F. W. SMALLEY,
 F.Z.S.

On Colour and Colour-pattern Inheritance in Pigeons.

Communications intended for the Scientific Meetings should
 be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
 REGENT'S PARK, LONDON, N.W.
February 28th, 1911.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

On the night of each Scientific Meeting Motor 'Buses will run direct to the Gardens from Regent's Park Tube Station, starting at 8.5 and 8.20 p.m. The return 'buses after the Meeting will leave the Gardens at 10.30 and 10.45 p.m. These 'buses will be labelled **PRIVATE** and no fare will be charged to Fellows attending the Meetings.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

March 7th, 1911.

Dr. A. SMITH-WOODWARD, F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

Mr. R. I. POCKOCK, F.L.S., F.Z.S., exhibited, on behalf of Mr. E. C. OBERHOLTZER, a large number of lantern-slides and photographs illustrating the habits of Moose. Mr. Oberholtzer had spent several months in the forested lakeland tributary to Rainy Lake, Ontario, photographing and observing the habits of Moose, and had presented to the Society the series of enlargements exhibited.

The SECRETARY exhibited a series of lantern-slides prepared from photographs kindly given to him by Mr. CARL HAGENBECK, Silver Medallist of the Society, and illustrating some of the most remarkable features of Mr. Hagenbeck's new Tierpark at Stellingen near Hamburg.

Dr. KARL JORDAN, F.E.S., and the Hon. N. CHARLES ROTH-SCHILD, M.A., F.Z.S., F.E.S., communicated a paper "On some Siphonaptera from Northern China." This collection of Fleas had been made by Mr. M. P. Anderson, the Duke of Bedford's collector, in the province of Shen-si, and contained altogether 17 species, of which no less than 13 were new. Some of these

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were possibly only geographical developments, but others represented distinct types not very nearly allied to any known species.

Mr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, read a paper dealing with certain points in the anatomy of the Frog *Megalophrys* (*Leptobrachium*) *feæ*, based on specimens which had been exhibited in the Society's Gardens.

Mr. BEDDARD also read a paper on the Spermatophores in Earthworms of the genus *Pheretima* (= *Perichaeta*). These structures had been found in two species, one of which would be described as new, contained in a collection of terrestrial Oligochaeta from the Philippine Islands, which had been submitted to him for examination by the Director of the Scientific Bureau of the Philippines.

Mr. R. LYDEKKER communicated two short papers entitled (a) "A Rare Beaked Whale," and (b) "Age Phases of the Rorqual."

Dr. P. CHALMERS MITCHELL, M.A., F.R.S., Secretary of the Society, gave an account of his memoir entitled "On Longevity and relative Viability in Mammals and Birds; with a Note on the Theory of Longevity." The work was based on a study of the records of the duration of life in the Society's Gardens of over 20,000 individual Mammals and Birds. These were arranged systematically so as to make possible a comparison of the average duration with the maximum duration and what was known or could be inferred as to the potential longevity. Such a method gave a measure of the effect of the conditions of captivity on the duration of life. The memoir discussed some of the results obtained by such a comparison, particularly with regard to the provision of artificial heat. In the note on the Theory of Longevity, the author briefly reviewed the contributions of Ray Lankester, Weismann, and Metchnikoff, and stated his conclusion that potential longevity was due to constitutional causes, that the constitution was adapted to the average specific longevity, and that the correlation between longevity and reproduction was the reverse of what had been suggested by Weismann.

The next Meeting of the Society for Scientific Business will be held on Tuesday, March 21st, 1911, at half-past Eight o'clock P.M., when the following communications will be made:—

1. MRS. E. W. SEXTON.

On the Amphipod Genus *Leptocheirus*.

2. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., and F. W. SMALLEY,
F.Z.S.

On Colour and Colour-pattern Inheritance in Pigeons.

3. G. STEWARDSON BRADY, M.D., LL.D., D.Sc., F.R.S., C.M.Z.S.

Notes on Marine Ostracoda from Madeira.

The following communications have been received:—

1. WILLIAM NICOLL, M.A., D.Sc., M.B.

On Three new Trematodes from Reptiles.

2. J. A. MÖRCH.

On the Natural History of Whalebone Whales.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.
March 14th, 1911.

MOTOR 'BUSES FOR THE SCIENTIFIC MEETINGS.

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NOTICE.

The 'Proceedings' for the year are issued in *four* parts, paged consecutively, so that the complete reference is now P. Z. S. 1911, p. . . . The Distribution is as follows:—

Part 1 issued in March.

„ 2 „ June.

„ 3 „ September.

„ 4 „ December.

'Proceedings,' 1910, Part IV. (pp. 837-1033), were published on January 11th, 1911.

The 'Abstracts of the Proceedings,' Nos. 87-92,
are contained in this Part.

PROCEEDINGS
OF THE
GENERAL MEETINGS FOR SCIENTIFIC BUSINESS
OF THE
ZOOLOGICAL SOCIETY
OF LONDON.
1911.

PART II.
CONTAINING PAGES 181 TO 555, WITH 15 PLATES
AND 93 TEXT-FIGURES.

JUNE 1911.

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THE ZOOLOGICAL SOCIETY OF LONDON.

THIS Society was founded in 1826 by Sir STAMFORD RAFFLES, Mr. J. SABINE, Mr. N. A. VIGORS, and other eminent Naturalists, for the advancement of Zoology and Animal Physiology, and for the introduction of new and curious subjects of the Animal Kingdom, and was incorporated by Royal Charter in 1829.

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The Society consists of Fellows, and Honorary, Foreign, and Corresponding Members, elected according to the By-Laws. It carries out the objects of its foundation by means of the collection of living animals, by its Library, and by its Scientific Publications.

The Office of the Society, where all communications should be sent, addressed to "The Secretary," is open from Ten till Five, except on Saturdays, when it closes at Two p.m.

The Library, under the superintendence of Mr. F. H. Waterhouse, is open daily at the above hours, except in September.

The Meetings of the Society for General Business are held on the third Wednesday in every month of the year, except in September and October, at half-past Four o'clock p.m.

The Meetings for Scientific Business are held fortnightly on Tuesdays, except in July, August, September, and December and January, at half-past Eight o'clock p.m.

The Anniversary Meeting is held on the 29th. of April, or the nearest convenient day, at Four p.m.

The Gardens are open daily from Nine o'clock until Sunset. Mr. R. I. Pocock, F.R.S., F.L.S., is the resident Superintendent and Curator of Mammals. Mr. D. Seth-Smith is Curator of Birds and Inspector of Works. The Prosectorium for Anatomical and Pathological work is under the charge of Mr. Frank E. Beddard, M.A., F.R.S., Prosector, assisted by Mr. H. G. Plimmer, F.R.S., M.R.C.S., Pathologist to the Society.

TERMS FOR THE ADMISSION OF FELLOWS.

FELLOWS pay an Admission Fee of £5, and an Annual Contribution of £3, due on the 1st. of January, and payable in advance, or a Composition of £45 in lieu thereof; the whole payment, including the Admission Fee, being £50.

No person can become a FELLOW until the Admission Fee and first Annual Subscription have been paid, or the annual payments have been compounded for.

FELLOWS elected after the 31st. of August are not liable for the Subscription for the year in which they are elected.

PRIVILEGES OF FELLOWS.

FELLOWS have Personal Admission to the Gardens upon signing their names in the book at the entrance gate, and may introduce Two Companions daily.

The WIFE or HUSBAND of a FELLOW can exercise these privileges in the absence of the Fellow.

Every FELLOW is entitled to receive annually 60 undated Green Cards, and, when no specific instructions are received, the supply will be sent in this form. If preferred, however, 20 Green Cards may be exchanged for a book containing 2 Orders for each Saturday* throughout the year. A similar book of Sunday Orders may also be obtained in lieu of 20 Green Cards. A Green Card may also be exchanged for 2 Buff Cards for the use of Children under 12 years of age.

It is particularly requested that Fellows *will sign every Ticket* before it goes out of their possession. Unsigned Tickets are not available.

Green and Buff Tickets may be used on any day and in any year, but in no case can two Children be admitted with one Adult's Ticket, or an Adult be admitted with two Children's Tickets.

The annual supply of Tickets will be sent to each FELLOW on the 1st. of January in every year, upon filling up and returning the form of Standing Order supplied to Fellows.

FELLOWS are not allowed to pass in friends on their written order or on presentation of their visiting cards.

FELLOWS are exempt from payment of the fee for Painting, Sketching, and Photographing in the Society's Gardens.

FELLOWS have the privilege of receiving the Society's ordinary Publications issued during the year upon payment of the additional Subscription of One Guinea. This Subscription is due upon the 1st. of January, and must be paid before the day of the Anniversary Meeting, after which the privilege lapses. FELLOWS are likewise entitled to purchase these Publications at 25 per cent. less than the price charged to the public. A further reduction of 25 per cent. is also made upon all purchases of Publications issued prior to 1881, if above the value of Five Pounds.

FELLOWS also have the privilege of subscribing to the Annual Volume of 'The Zoological Record,' which gives a list of the Works and Publications relating to Zoology in each year, for the sum of

* The Saturday Orders are not available if the Fellow introduces friends personally on that day.

One Pound Ten Shillings. Separate divisions of volumes 39 to 42 can also be supplied. Full particulars of these publications can be had on application to the Secretary.

FELLOWS may obtain a TRANSFERABLE IVORY TICKET admitting two persons, available throughout the whole period of Fellowship, on payment of Ten Pounds in one sum. A second similar ticket may be obtained on payment of a further sum of Twenty Pounds.

Any FELLOW who intends to be absent from the United Kingdom during the space of at least one year, may, upon giving to the Secretary notice in *writing*, have his or her name placed upon the "dormant list," and will then be called upon to pay an annual subscription of £1 only during such absence, but after three years must make a further application to be retained on that list.

Any FELLOW, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with the undersigned.

P. CHALMERS MITCHELL,

Secretary.

Regent's Park, London, N.W.,
June, 1911.

MEETINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON
FOR
SCIENTIFIC BUSINESS.

1911.

TUESDAY, OCTOBER 24

,, NOVEMBER 7 & 21

*The Chair will be taken at half-past Eight o'clock in the Evening
precisely.*

ZOOLOGICAL SOCIETY OF LONDON.

THE ZOOLOGICAL RECORD.

THE object of the ZOOLOGICAL RECORD is to give, by means of an annual Volume, complete lists of the Works and Publications relating to Zoology in all its branches that have appeared during the year preceding the issue of the Volume, together with full information as to the points they deal with, arranged in such a manner as to serve as an Index to the literature of Zoology in all parts of the globe, and thus to form a repertory that will retain its value for the Student in future years.

The 'Zoological Record' having been amalgamated with the International Catalogue of Scientific Literature, Zoology, Volumes from 43 onwards can now be obtained only from Messrs. Harrison & Sons, except when purchasing complete sets from the Zoological Society.

Under the scheme of amalgamation, Fellows of the Society, and Institutions already on the subscription-list, have the privilege of subscribing at the old rate of 30s. per annum, which covers the cost of carriage of the volume. The subscription becomes due on July 1st. in each year, and lapses if not paid by the 1st. of December following.

The Society is able to supply complete sets of the Record on the following terms:—

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Vol. 42 at 40s. The price of the 'Zoological Record,' Vol. 43 and subsequent volumes, published now by Messrs. Harrison and Co., is 40s. each.

INDEX ZOOLOGICUS. An alphabetical list of names of genera and subgenera proposed for use in Zoology, as recorded in the 'Zoological Record,' 1880-1900; together with other names not included in the 'Nomenclator Zoologicus' of S. H. Scudder. Compiled (for the Zoological Society of London) by CHARLES OWEN WATERHOUSE and edited by DAVID SHARP, Editor of the 'Zoological Record.' London, 1902. Price to Fellows, 18s.; price to the public, 20s., or if sold with a set, 10s.

Divisions of the 'Zoological Record' of Vols. 39 to 42 can be supplied by the Society, but *after* Vol. 42 they can be had only of Messrs. Harrison & Sons, 46 St. Martin's Lane, W.C.

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P. CHALMERS MITCHELL,

Secretary.

REGENT'S PARK, LONDON, N.W.

June, 1911.

ZOOLOGICAL SOCIETY OF LONDON.

LIST OF PUBLICATIONS.

THE scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in an octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

The "Proceedings" for each year are issued in four parts, pagged consecutively, on the first of the months of March, June, September, and December. From January 1901 they have been issued as two half-yearly volumes, indexed separately.

An "Abstract of the Proceedings" is published by the Society on the Tuesday following the date of Meeting to which it refers. It is issued along with the "Proceedings," free of extra charge, to all Fellows who subscribe to the Publications, but it may be obtained on the day of publication at the price of Sixpence, or, if desired, sent post free for the sum of Six Shillings per annum, payable in advance.

The "Transactions" contain such of the communications made to the scientific meetings of the Society as, on account of the nature of the plates required to illustrate them, are better adapted for publication in the quarto form. They are issued at irregular intervals.

Fellows and Corresponding Members, upon payment of a Subscription of One Guinea *before* the day of the Anniversary Meeting in each year, are entitled to receive the Society's Publications for the year. They are likewise entitled to purchase the Publications of the Society at 25 per cent. less than the price charged for them to the Public. A further reduction of 25 per cent. is made upon purchases of Publications issued prior to 1881, if they exceed the value of five pounds.

Fellows also have the privilege of subscribing to the Annual Volume of the Zoological Record for a sum of 30s. (which includes cost of delivery), payable on the 1st. of July in each year; but this privilege is forfeited unless the subscription be paid *before* the 1st. of December following.

The following is a complete list of the publications of the Society already issued.

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* In consequence of a re-arrangement of the stock of the 'Transactions,' the Society is now able to offer for sale, at the reduced price of £30, sets of Vols. v.-xvi. inclusive, and separate papers, of which a list can be supplied, at about one-fourth their published price.

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P. CHALMERS MITCHELL,

Secretary.

Regent's Park, London, N.W.,
June, 1911.

*These publications may be obtained at the SOCIETY'S OFFICE,
at Messrs. LONGMANS' (Paternoster Row, E.C.), or through any
bookseller.*

EXHIBITIONS AND NOTICES.

February 7, 1911.

Prof. E. A. MINCHIN, M.A., Vice-President,
in the Chair.

THE SECRETARY read the following report on the additions made to the Society's Menagerie during the month of December, 1910:—

The registered additions to the Society's Menagerie during the month of December were 133 in number. Of these 76 were acquired by presentation, 27 by purchase, 12 were received on deposit, 17 in exchange, and 1 was born in the Gardens.

The total number of departures during the month, by death and removals, was 216.

Amongst the additions special attention may be called to the following:—

1 Viverrine Cat (*Felis viverrina*), from India, 1 Northern Lynx (*Felis lynx isabellinus*), from Tibet, 2 Binturongs (*Arctictis binturong*), from Malacca, and 1 Yellow-throated Marten (*Mustela flavigula*), from India, purchased on Dec. 24th; 4 Canadian Skunks (*Mephitis mephitis*) and 2 Little Skunks (*Spilogale putorius*), from N. America, the latter new to the Collection, purchased on Dec. 29th.

1 Silver Fox (*Vulpes argentatus*), from Hudson's Bay, received in exchange on Dec. 12th.

1 Feline Otter (*Lutra felina*), new to the Collection, from La Plata, presented by William Clyne, Esq., on Dec. 6th.

1 Brindled Gnu (*Connochates taurinus*), born in the Menagerie on Dec. 1st.

A collection of 15 Reptiles, including 1 Raddon's Lizard (*Mabuia raddonii*), 1 Smyth's Snake (*Grayia smythii*), and 1 Yellow-throated Snake (*Thrasops flavigularis*), new to the Collection, from Dunkwa, Gold Coast, presented by Dr. H. G. F. Spurrell on Dec. 12th.

Dr. C. W. ANDREWS, F.R.S., F.Z.S., exhibited the skull of a Sabre-toothed Tiger (*Smilodon californicus*), from an asphalt deposit in California, and pointed to anatomical characters which tended to prove that the animal used its large canines for stabbing and tearing, not for biting.

THE SECRETARY exhibited a mounted specimen of the Platypus (*Ornithorhynchus paradoxus*), which had been lent for the purpose by Mr. P. St. Michael Podmore, F.Z.S.

MR. EDWARD GERRARD, F.Z.S., exhibited the head of a Caribou (*Rangifer tarandus caribou*) (text-fig. 52), shot by Sir John Rogers, K.C.M.G., in British Columbia, which had a distinct forked third antler over the centre of the orbital arch of the frontal bone just

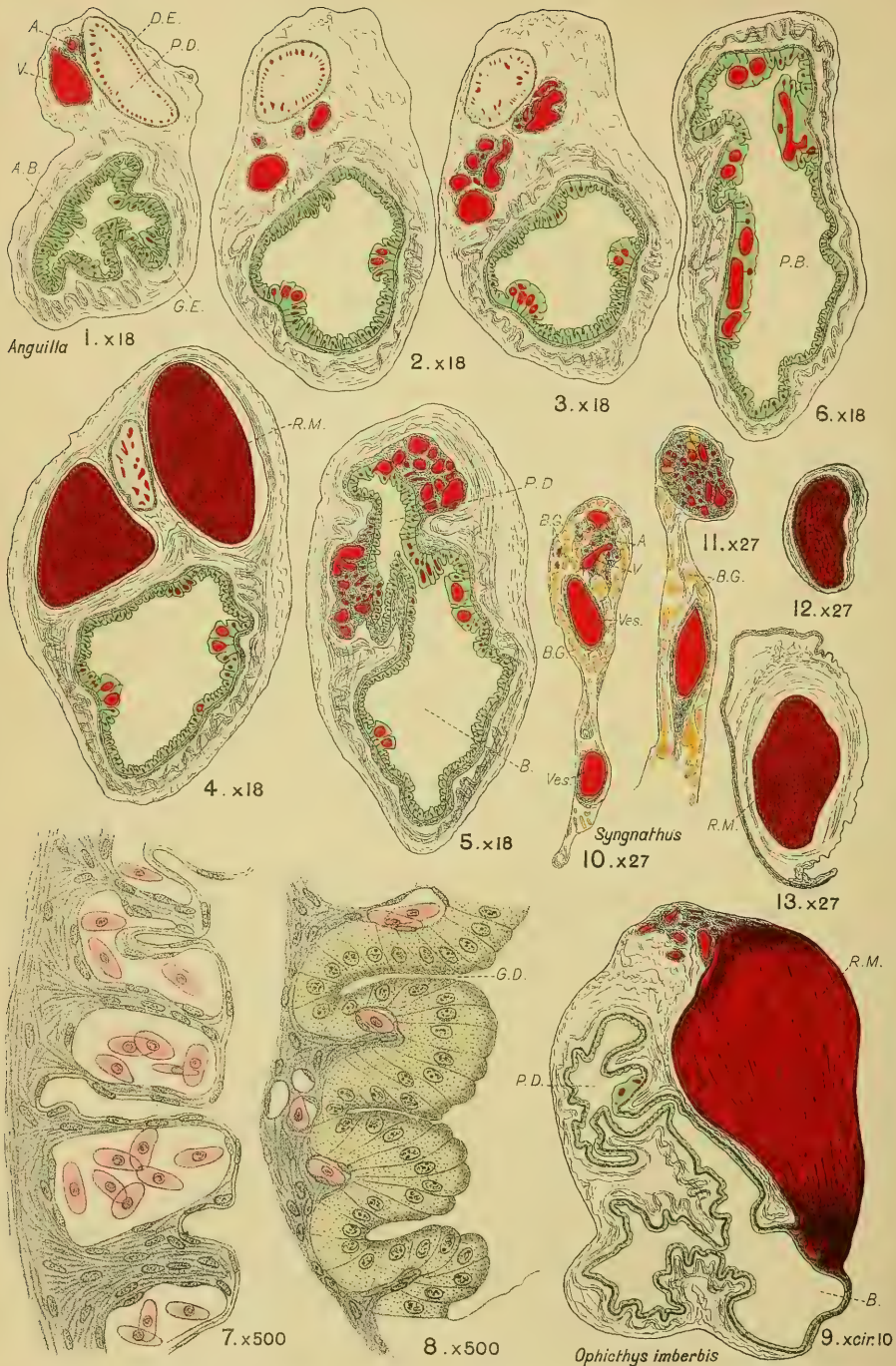
in front of the normal antler, which carried a single anterior basal tine, and separated from it by a strip of hairy skin. There was a slight burr on a level with the skin, but no pedicle. It had the appearance as if it could be shed in the same manner as the normal antlers.

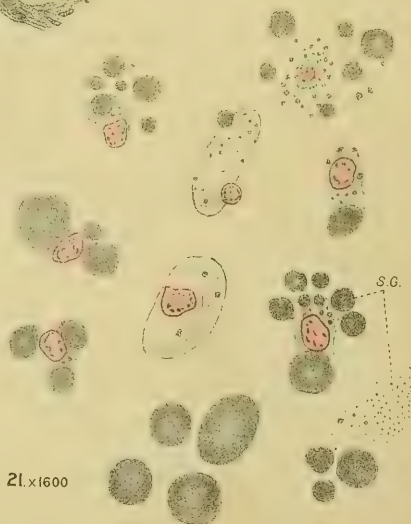
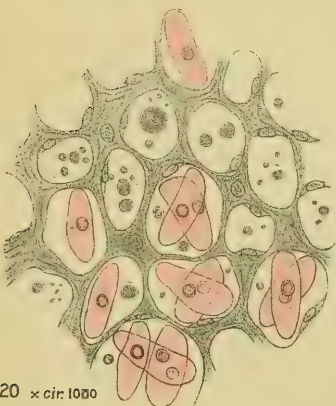
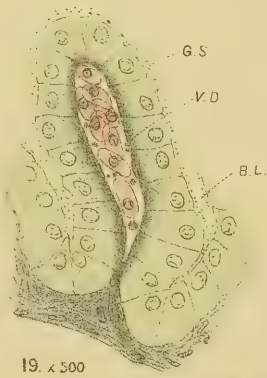
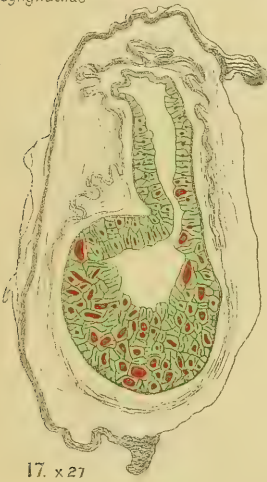
Text-fig. 52.

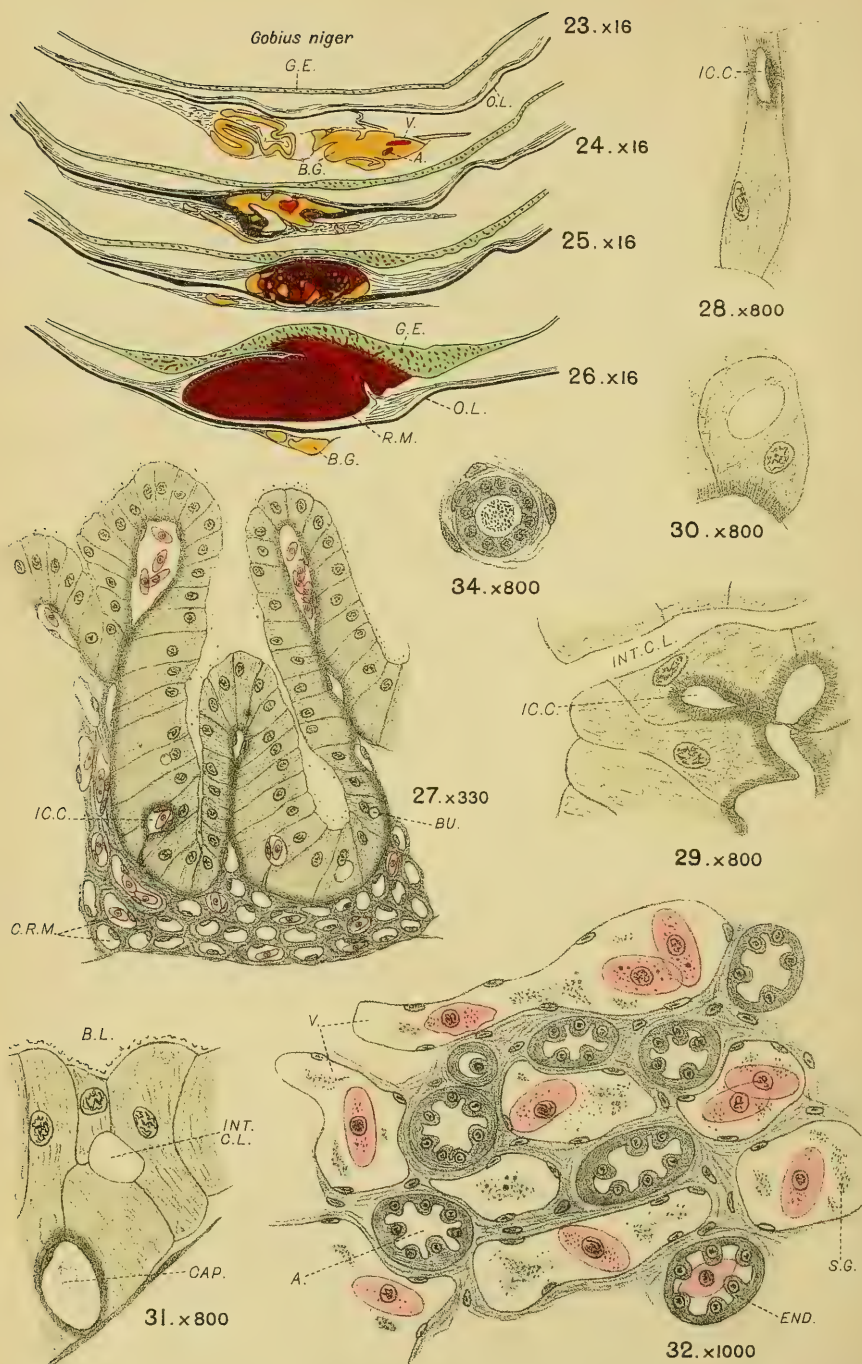


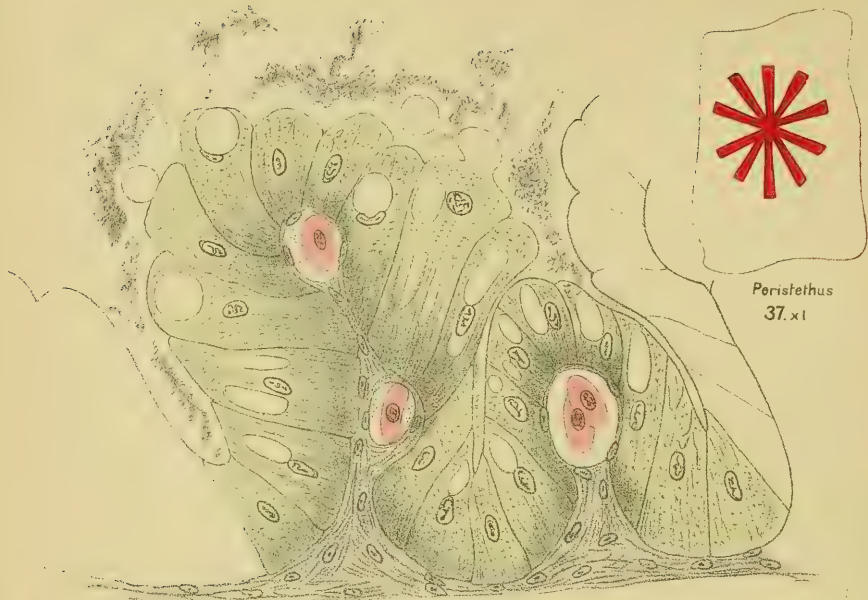
Head of a Caribou (*Rangifer tarandus caribou*) with abnormal antlers.

A very fine head of an Eland (*Taurotragus derbianus gigas*) obtained by Major Gordon on the Bahr-el-Ghazel, and three fine heads of White-tailed Deer (*Dorcelaphus americanus macrurus*) were also exhibited, one pair of antlers being abnormal.



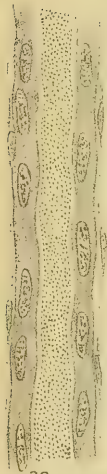






Peristethus
37. x1

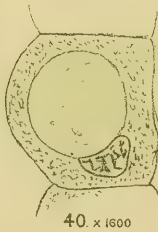
Gobius minutus
35. x1000



33. x800
Gobius niger



Siphonostoma
36. x1000



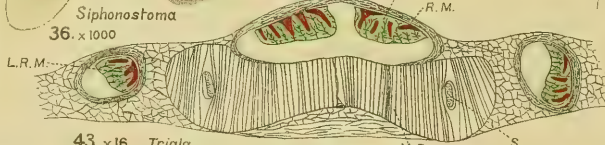
40. x1600



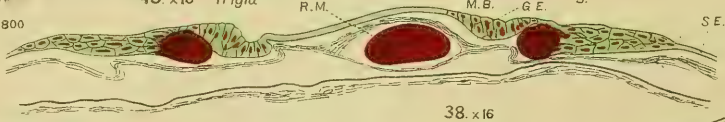
39. x1600



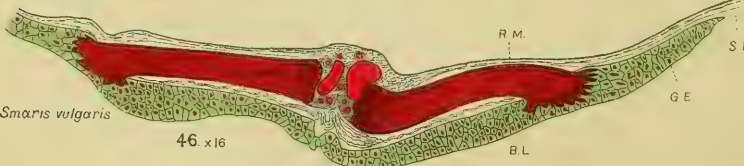
41. x1600



43. x16 Trigla

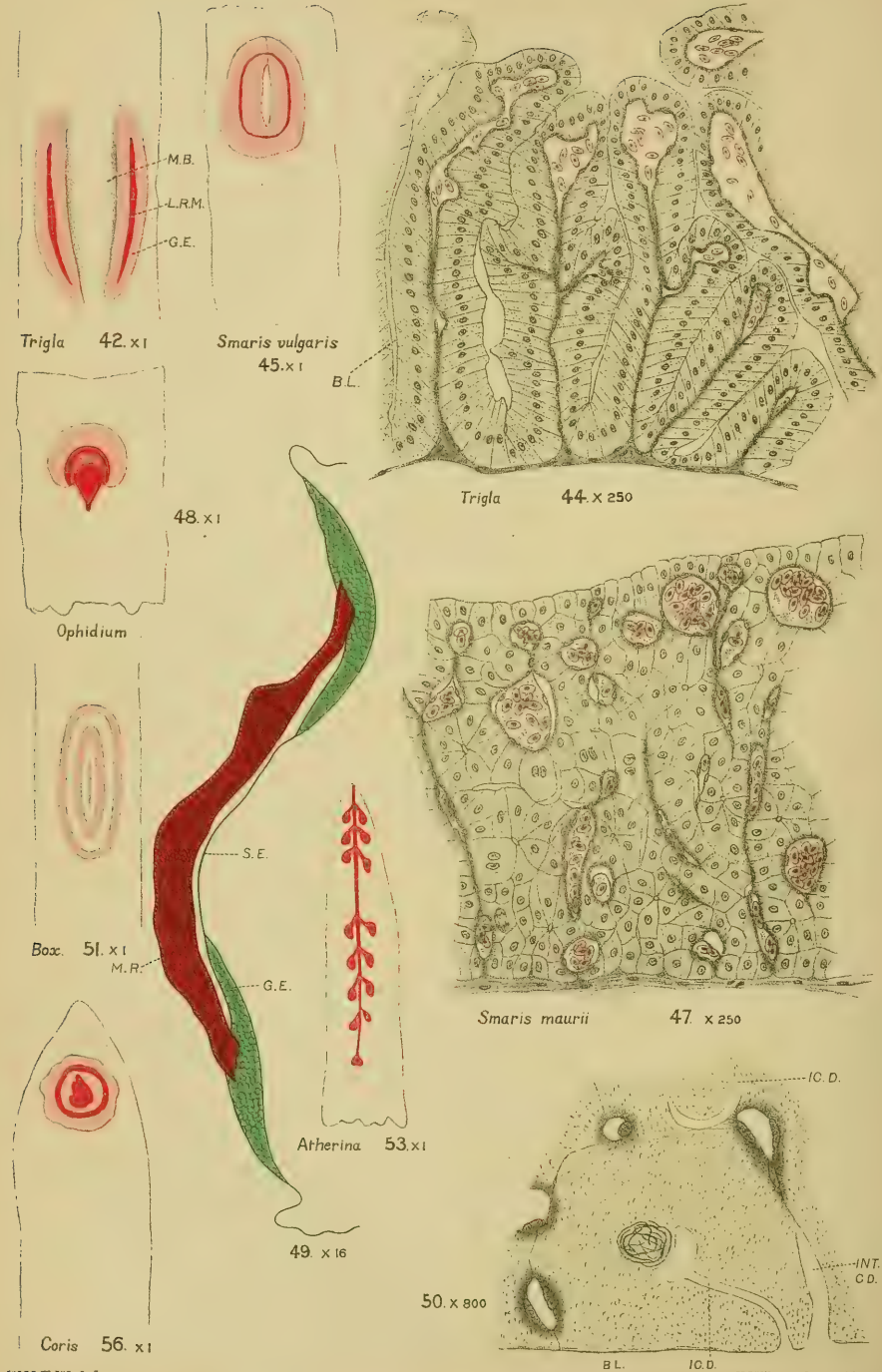


38. x16



Smaris vulgaris

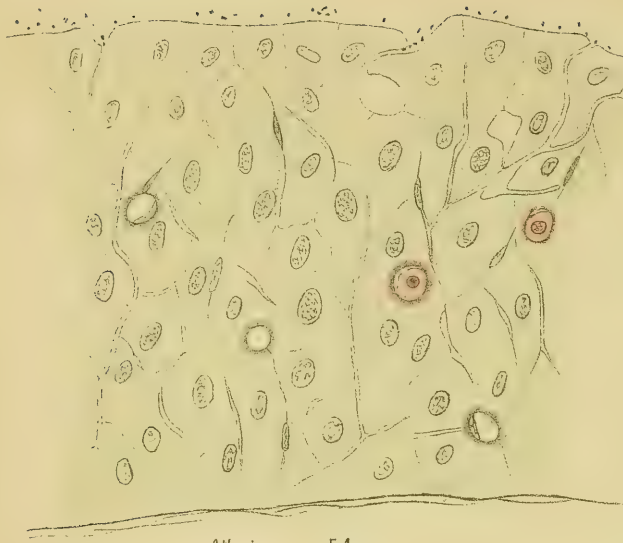
46. x16



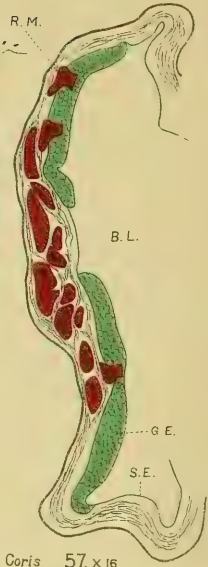
W.N.F.W. del.

GAS GLANDS OF TELEOSTEI.

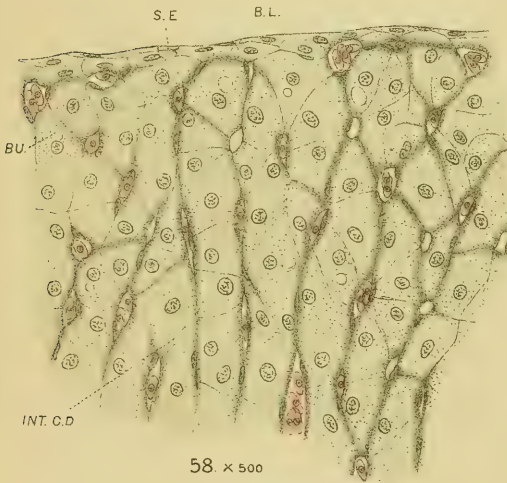
E. Wilson, Cambridge.



Atherina 54. x 1000



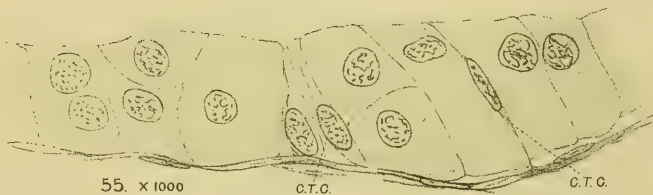
Coris 57. x 16



58. x 500



Boac 52. x cir 27



55. x 1000

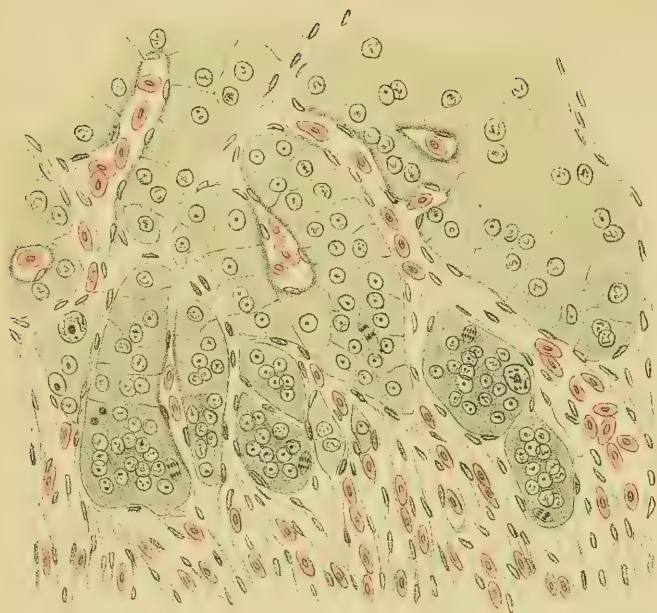
C.T.C.

C.T.C.



Corvina

59. x 1



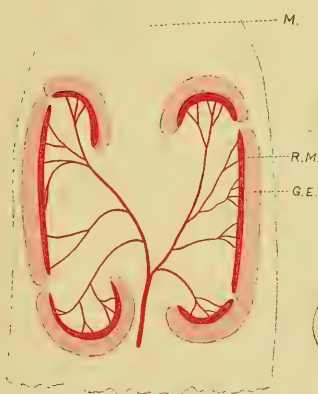
63. x 375



Sargus 60. x 1



Balistes 61 x 1



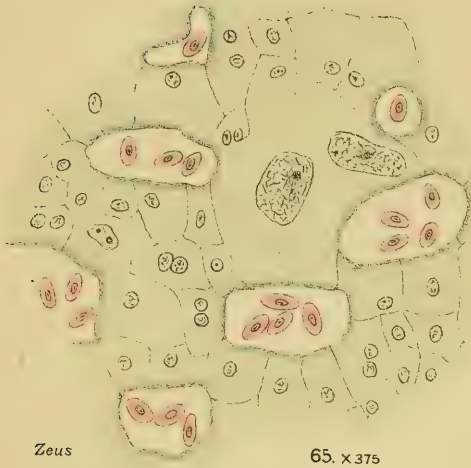
Zeus 62. x 1



64. x 666

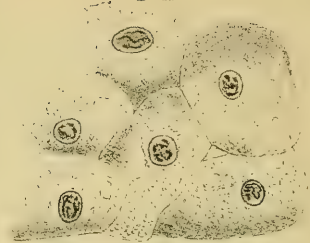


Cepola
67 x 1



Zeus

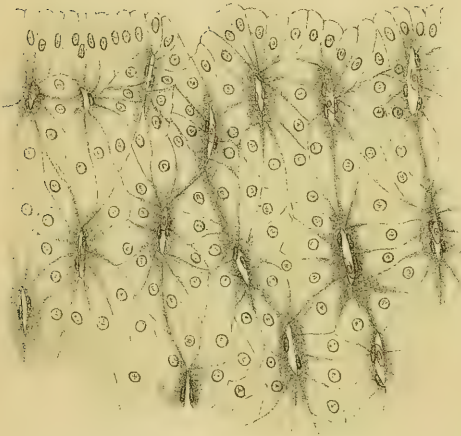
65. x 375



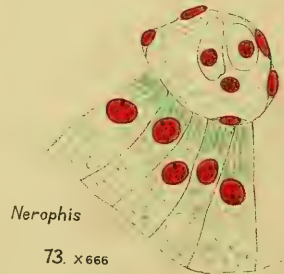
71. x 1000



72. x 1000

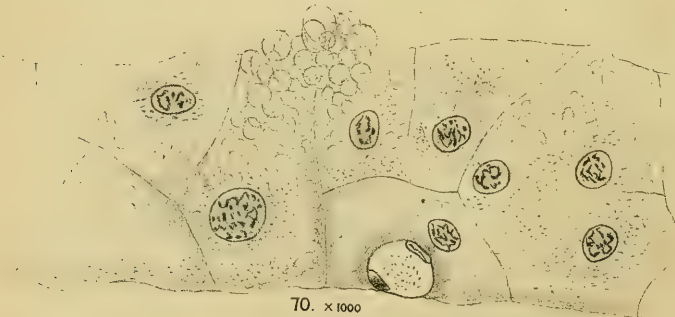


Cepola 68. x 333



Nerophis

73. x 666



70. x 1000

Perca



69. x 1

PAPERS.

11. On the Structure and Function of the Gas Glands and Retia Mirabilia associated with the Gas Bladder of some Teleostean Fishes, with Notes on the Teleost Pancreas. By W. N. F. WOODLAND, F.Z.S., The Zoological Department, University College *, London.

[Received November 9, 1910; Read February 7, 1911.]

(Plates II.-IX.† and Text-figures 53-62.)

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INTRODUCTORY.

In the present paper it is proposed to give a fairly complete account of the gross and histological structure of the vasculo-glandular organs or "red bodies" found in the wall of the gas bladder ‡ of many teleost fishes, and to offer certain suggestions

* The greater part of the work connected with the present paper was carried out in the Zoological Department of King's College, London.

† For explanation of the Plates see pp. 245-248.

‡ The terms "swim-bladder" and "air-bladder" are inappropriate, since fishes do not use this apparatus for swimming and it does not contain air.

respecting the physiology of these organs. Though the literature * concerned with the morphology and physiology of the gas bladder is, of course, very considerable, yet up to the present only one author (64, 65) has attempted a complete review of the subject of the present paper in the light of recent work. Further, although there exist several memoirs dealing with special types of "red body," yet most of these are so occupied with cytological and other details that, in the opinion of the present writer, they have failed to supply such an account and such illustrations of the gross structure of these "red bodies" as to render evident some of their most remarkable features. Finally, the Jaeger-Nusbaum controversy calls for an independent description of these unique organs, so interesting from the physiological standpoint.

I have divided the present paper into two parts, the first of which deals with the structure and the second with the physiology of the "red bodies." With reference to the drawings illustrating Part I., I have, with a few exceptions, adopted a definite scheme of coloration in order to facilitate comprehension. Green has been adopted to denote the internal lining epithelium of the bladder, and therefore the glandular, *i. e.* gas gland, epithelium is always of this colour in the drawings, since this is but a special development of the usually squamous lining epithelium; red denotes blood; black or grey has been employed for connective and muscular tissue and secretion material; and yellow has been used to indicate the pancreas, which is often closely associated in a mechanical sense with some parts of the "red body." The sources and methods of preparation of my material are stated in Appendix A (p. 236).

PART I.—THE STRUCTURE OF THE "RED BODIES" IN VARIOUS TELEOSTEI.

It is necessary to recognize at the outset that the term "red body" unfortunately has been applied to different structures by no means equivalent to each other: thus, *e. g.*, the "red bodies" of the Common Eel are simply the two retia mirabilia, whereas the "red body" of the Cod consists both of numerous small retia mirabilia and of the large mass of epithelial cells called the gas gland, the retia and the gas gland being, in this case, intimately associated. A gas gland exists in the Eel as in all other fish with "red bodies," but it is not in close connection with the rete mirabile as in the Cod. This being the case, it must be understood that by the term "red body" all that is meant is a red mass situated in the bladder-wall, the constitution of which is variable. I may add that in the vast majority of cases "red body" includes both rete mirabile and gas gland. As an introduction to the study of gas gland structure I shall first describe the anatomy of one of the most simple as well as most common

* For the literature and historical reviews of the entire subject of gas bladders up to 1866 see Milne-Edwards (49) and Gouriet (34); for more recent literature see the lists supplied by Bridge (22), Hüfner (38), Jaeger (44), Deineka (29), Reis & Nusbaum (62, 63), and at the end of the present paper.

forms, viz. that of the Common Eel, *Anguilla vulgaris*. The "red body" of the Eel has been described several times previously, e. g. by Jacobs (42, 43), Quekett (61), and Corning (28), but never, I venture to think, in a sufficiently clear or comprehensive manner and certainly never adequately illustrated.

The Vasculo-glandular Structure in the Bladder of the Common Eel
(*Anguilla vulgaris*).

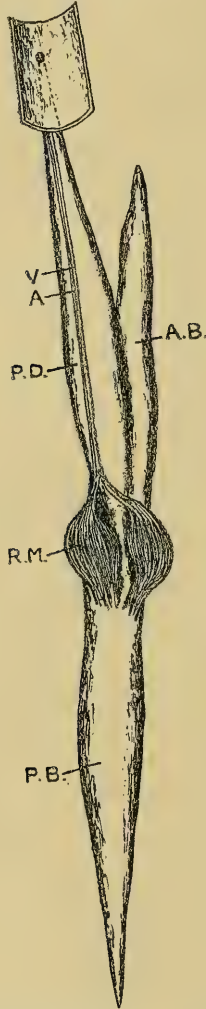
It is well known that the bladder of the Eel is an elongated sac lying dorsally and towards the posterior end of the body cavity and connected with and opening into the œsophagus by means of a long wide duct—the ductus pneumaticus (text-fig. 53, P.D., p. 186). The pneumatic duct opens into the bladder at about midway in its length, the bladder in consequence being divisible into anterior (A.B.) and posterior (P.B.) regions. The bladder and duct are both situated in the same horizontal plane, i. e. the duct opens into the bladder at the side, not dorsally or ventrally. Running along the ventral side of the duct are an artery and a vein situated close together (A.V.). This artery and vein give rise to the two ovoid retia mirabilia (R.M.) where the duct opens into the bladder, the two retia lying one on each side of the duct and therefore being dorsal and ventral in position respectively and in the same vertical line.

The wall of the bladder (see Pl. II. figs. 1-6, e. g.) in fish generally is best described as consisting of the tunica externa and tunica interna. The former consists of two definite layers of fibrous tissue, the outer being loose in texture, often containing muscular tissue and varying greatly in thickness, the inner dense, silvery in appearance, and principally consisting of elastic fibres. The latter consists of a thin basis of dense connective tissue, with which is closely connected the innermost layer of the bladder wall, a layer consisting usually of flattened cells. It is this innermost cellular layer which gives rise to the mass of glandular cells in connection with a rete mirabile—the gas gland. The tunica interna is easily separable from the tunica externa, and it is advisable to remove this latter before cutting sections of the gland.

The vascular supply of the bladder may first be considered. It has already been mentioned that an artery and a vein run along the ventral side of the wall of the ductus pneumaticus. These two vessels are situated in the outer fibrous layer of the tunica externa (Pl. II. fig. 1), which is here of considerable thickness, and they supply several arteries to the duct and receive several veins from it. Shortly before these two vessels reach the region of the junction of the duct with the bladder, the artery and the vein each divide into two (fig. 2), so that there are two pairs of vessels instead of one, each pair consisting of an artery and a vein. Now the artery and vein of each of these pairs undergoes further subdivision, the smaller arteries and veins resulting from this subdivision intermingling in their course, but not once communicating with each other, so that we now have situated towards

the upper and lower sides of the ductus pneumaticus two distinct masses of intermingled arteries and veins (fig. 3), each mass having resulted from the subdivision of the two pairs of arteries and veins, which, as we have seen, have themselves originated

Text-fig. 53.



The bladder, duct, and "red bodies" of *Anguilla vulgaris*,
viewed from the side (after Quekett).

P.D., pneumatic duct which opens anteriorly into the œsophagus; A and V, artery and vein supplying bladder; R.M., rete mirabile; A.B., anterior region of bladder; P.B., posterior region of bladder.

by the division of the initial artery and vein. The subdivision of the arteries and veins in each mass proceeds rapidly, until there is formed by this process an ovoid mass of extremely fine parallel arterial and venous capillaries, closely intermingled with each other, but never intercommunicating and indistinguishable structurally as arteries and veins under the highest powers of the microscope (fig. 4). These two ovoid masses of parallel arterial and venous capillaries lying on the dorsal and ventral sides of the ductus pneumaticus just anterior to its junction with the bladder are the retia mirabilia of the eel-bladder (text-fig. 53, R.M.).

The finest arterial and venous capillaries of each rete mirabile run parallel to each other for a short distance, but soon they commence to unite, arterial capillaries with arterial capillaries and venous with venous, in order to re-form larger vessels similar to those which produced the capillaries by subdivision. This process of reunion proceeds so far as to form two masses of large intermingled arteries and veins similar to those depicted

Text-fig. 54.



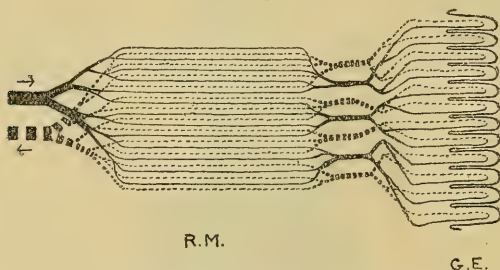
External aspect of a rete mirabile (after Quekett). The anastomoses of the vessels shown in this figure do not occur in actuality.

in figure 3 (*cf.* figs. 3 & 5). When reunion has proceeded thus far, each of these masses of re-formed arteries and veins once more breaks up into fine capillaries in connection with the vascular supply of the glandular folded epithelium which lines the bladder internally. I reproduce here as faithfully as I am able (text-fig. 54) Quekett's figure (61) of the construction of the Eel's rete mirabile, which illustrates in a general way that which I have just described. Text-fig. 54 is unsatisfactory in that it does not indicate the fact that the vessels and capillaries forming the rete are of two kinds—arterial and venous—closely intermingled with each other, although never intercommunicating; also anastomoses never occur between adjacent large vessels in the manner shown in the figure. A more satisfactory diagram of the construction of the Eel's rete mirabile is the one I have

designed for text-fig. 55. In this the artery and the vein giving rise to a rete mirabile are distinguished from each other by the latter being cross-striated, the subdivision of each of them is indicated, also the intermingling of the fine parallel capillaries, their reunion and the second breaking up into capillaries of the large arteries and veins thus formed to supply the epithelium of the gas gland.

Up to the present I have spoken of the arterial and venous capillaries or vessels composing each of the two retia mirabilia merely as tubes, but if, of course, we take into account the direction of the flow of blood in the two sets of vessels, then it is evidently incorrect to speak of the arteries and veins both subdividing at the anterior pole of the rete mirabile to produce

Text-fig. 55.



The construction of the rete mirabile bipolare geminum (R.M.).
G.E., glandular epithelium of gas gland.

capillaries: what is really happening in this region is that the arteries are subdividing and the veins uniting (text-fig. 55). That this is the actual mode of construction of the rete mirabile is not only proved by the study of serial sections but also by the injection method. And here let me remark upon the extraordinary process implied by this construction of the rete mirabile—a term which, like its German rendering, “wunder-netze,” happens to be peculiarly appropriate*. It is implied that parallel vessels carrying blood in opposite directions can so influence each other, or be so influenced by a common cause, as to break up into a rete mirabile at the same spot, the subdivision of each of the two sets of vessels being so adapted to the other as to ensure the close apposition and intimate intermingling of their finest capillaries†. It is evident that this intricate

* Müller (53) termed this type of rete mirabile a “rete mirabile bipolare geminum,” in contradistinction to a “rete mirabile bipolare simplex,” such as the purely arterial carotid gland of Amphibia.

† The fact illustrated by these retia that blood-vessels are able to capillarize on their own account, *i. e.* quite apart from any other tissue, first attracted my attention to these “red bodies” when engaged in certain speculations concerning the “renal-portal system” in Vertebrates (76, 77). The formation of the retia seems to lend support to Dr. Shore’s views (68, 69) concerning the vascularization of the liver as distinguished from the venous penetration of the kidney-substance to form the “renal-portal system.” I hope shortly to investigate the subjects of the “renal-portal system” and the various kinds of retia mirabilia from a practical standpoint.

mechanism must be for some definite purpose, especially since it is found in all fishes possessing gas glands. What that purpose may be is a question I shall discuss later (see Part II.).

The epithelium lining the ductus pneumaticus, which is supplied with a few branches direct from the bladder artery and is therefore not supplied by the vessels connected with the retia mirabilia, is quite simple in character. It merely consists of a single layer of flattened cells raised up at intervals by the large capillaries running in the basis of connective tissue underlying the epithelium (Pl. II. fig. 7). These capillaries in the wall of the duct apparently have much the same surface arrangement as those found in the lungs of certain reptiles (Quekett, 61), but it is hard to suppose from this fact alone that the epithelium of the duct is normally respiratory in function, since the blood supplied to this has already been oxygenated in the gills; on the other hand, it is equally improbable that the arterial blood in the wall of the duct serves to alter the composition of the adjacent gas since there is reason to suppose that the duct normally serves as a mere exit for the superfluous gas of the bladder (Jaeger, 45). It is possible, however, that this large vascular supply of the duct epithelium in the Eel is really correlated with the terrestrial habits of the animal, since when an Eel travels across a meadow the gills are useless for obtaining oxygen, and under these circumstances the animal doubtless draws upon the oxygen in the bladder—the duct acts as a lung. Moreau proved that Perch, when placed in water previously boiled so as to deprive it of dissolved air, utilized the bladder-oxygen for purposes of respiration. An interesting confirmation of this view is that in other physostomes (*Myrus*, *Ophichthys*, *Esox*) the duct epithelium is, as we shall see, practically devoid of capillaries*.

—The lining epithelium of the bladder proper is very different in character from that of the duct. It consists of a more or less folded single layer of cells which are large in size and short columnar in form, slightly granular, and, when stained by the picro-indigo-carminine method (Appendix A), usually rather opaque (Pl. II. fig. 8). The folding of this layer is due to the presence of large capillaries which push their way inwards towards the bladder-cavity from the connective tissue base, and in so doing cause the epithelial layer to form corresponding emergences. Thus the interior of each projection of the glandular epithelium into the bladder cavity is occupied by an extension of connective tissue enclosing capillaries. The spaces situated between such emergences adjacent to each other are also regarded as forming gland ducts. The folding of the epithelium is very variable in different parts of the bladder wall, in some parts almost disappearing and in others being more accentuated than that depicted in figure 8; this folding is much more marked in the anterior region of the bladder than in the posterior. It might appear to be significant that immediately the lining epithelium of the duct becomes supplied with blood connected with the rete mirabile system of vessels

* I find that Jacobs (42, 43) states this view as a fact.

(that is, when the duct opens into the bladder) it then assumes the glandular folded character of the bladder epithelium, were it not for the fact that in other physostomous genera this sharp distinction between duct- and bladder-epithelium is absent, as I shall show shortly.

The intracellular structures described in detail below as being present in the cells of the gas glands of other teleost fishes—intracellular gas bubbles, capillaries, and ducts—are not easily to be detected in my preparations of the Eel, but I believe I have seen gas bubbles present in a few cases, also the capillaries occasionally intrude somewhat upon the cells at their bases. Granular matter, ejected into the bladder-cavity with the gas, is so small in amount in the gland ducts of my preparations that it may be said to be absent.

The folded glandular epithelium of the gas gland of the Eel, and presumably of all other genera possessing a folded epithelium, originates from a single unfolded layer which during development becomes pushed out into the folds by the activity of the large capillaries situated in the thin layer of connective tissue lying at the base of the epithelium*.

Thus in the type of "red body" found in the Common Eel we have two large retia mirabilia, situated some distance from the epithelium of the bladder which they supply, and the greater part of this lining epithelium of the bladder is glandular and folded in a simple manner to form the gas gland. In all "red bodies" we have these two elements, the rete mirabile and the gas gland, but in the majority of "red bodies" these two elements are much more intimately associated with each other and more complex in form as compared with the structure of the simple type of "red body" just described. The Eel type of "red body" serves as a convenient starting-point for considering more complex types.

Before considering these types, it is necessary to point out a serious mistake contained in almost the only English paper dealing with the present subject, that of Vincent and Barnes (75), which, though the paper is now quite out of date, has found its way into at least one recent text-book ('Cambridge Natural History,' vol. vii. 1904, p. 308). Vincent and Barnes, following Coggi (25), state that "red glands are only found in those bladders which are devoid of a ductus pneumaticus," and they draw a sharp distinction between Physoclisti, which possess the gas gland, and Physostomi, which are supposed to be devoid of one. I need hardly say that no such distinction exists. Vincent and Barnes are right, in so far as they say that the "red bodies" of the Eel are only partially comparable with those of the Gadidae (*vide supra*), but it is difficult to understand how they came to overlook the large and conspicuous glandular epithelium lining the bladder cavity. Further, as Deineka (29) points out, in the physostomous Pike (*Esox lucius*) a conspicuous gas gland

* I am much indebted to Dr. W. G. Ridewood for kindly presenting me with most of my young material.

exists (described by Coggi, 26), comparable in all essential respects with that of the Cod. Also Vincent and Barnes, unlike many of their predecessors, altogether fail to appreciate the peculiarity of the arterial and venous nature of the rete mirabile; indeed, they even appear to have some doubt as to the fact itself. They say: "Corning has discriminated between arteries and veins in what we have usually spoken of as the 'capillary masses.' This he has done by means of a series of injections. . . . This method would certainly give some idea of the distinction between the smallest arterioles and smallest venules, but we are doubtful whether it would be more than a very rough method of distinction, that it would be, in any given case, an infallible test as to whether a particular small vessel were to be called artery or vein. Much would depend, it appears to us, on the strength of the injecting force [1]. However this may be, we have failed to make out anything in the minute structure which would warrant us in dividing up the 'capillary masses' into arterioles and venules." This statement suggests that Vincent and Barnes never worked through a series of sections of the Eel (or any other similar) "red body" (which possibly also accounts for their missing the glandular epithelium of the Eel, which, as above stated, lies separate from and posterior to the retia mirabilia*), since the arterial and venous nature of the rete mirabilia is rendered quite evident by this means alone; also the last-quoted statement of Vincent and Barnes is still less comprehensible when we remember that these "red body" retia mirabilia have been correctly described in full and compared with the several other kinds of retia mirabilia which exist by Johannes Müller (53) in 1840, not to mention Owen's description (not confirmed by his figure, however) of the "red body" of the Eel just referred to †.

U. *Vasculo-glandular Structures of the Anguilla or First Type in the Bladders of some other Anguilliformes.*

MYRUS VULGARIS Kaup.

In this physostome the vascular and glandular conditions are similar to those found in *Anguilla vulgaris*. The only essential distinction between the two is in the character of the lining epithelia of the duct and bladder, and in this particular the

* A fact clearly stated by Owen ('The Comparative Anatomy and Physiology of Vertebrates,' vol. i. 1866, p. 495): "The two chief 'retia mirabilia' or vaso-ganglions, in the air-bladder of the Eel and Conger, which are situated at the sides of the opening of the air-duct, are also 'bipolar' and consist of both arterioles and venules [curiously enough, however, in contradiction of this statement, the figure 329 of the 'vaso-ganglion' of the Eel supplied on p. 496 shows the blood going through all capillaries in one direction!]: they consist of straight parallel capillaries, as in fig. 329; their afferent trunks do not ramify in the immediate margin of the vaso-ganglion from which they issue, as in the vaso-ganglions of the Cod, Burbot, Acerine, and Perch, but run for some distance before they again branch to form the common capillary system of the lining membrane of the air-bladder."

† These criticisms must not be held to imply any lack of appreciation of a very lucid and interesting paper; the fact, however, that the statements criticised have been made use of by the late Professor Bridge so recently as 1904 shows the need for correction.

distinction is striking. In *Anguilla* the epithelia of the duct and bladder are, as we have seen, quite different in character; in *Myrus vulgaris*, on the other hand, they are very similar. The duct epithelium consists of a single layer of short columnar cells which is only slightly folded. Very few capillaries are present in the connective tissue layer underlying the epithelium, though here and there large capillaries are to be seen in transverse section. Thus the duct is not lined by squamous epithelium as in *Anguilla*. In the bladder of *Myrus vulgaris* the epithelium is, as just stated, similar to that of the duct, the only difference being that the cells are larger. The folding of the epithelium is at most very slight and most pronounced in the region of the opening of the duct; in the anterior and posterior regions of the bladder, folding of the epithelium is practically absent. There is never any approach to the degree of folding seen in *Anguilla*. It is also noticeable that where the epithelium passes over a large capillary (and capillaries are not very numerous) the cells immediately assume a more squamous character.

OPHICHTHYS (SPLEGEBRANCHUS) IMBERBIS Delar.

In this physostome the plan of construction of the "red body" is essentially the same as that found in *Anguilla* and *Myrus*, but there exists in the single specimen at my disposal one modification in connection with the rete mirabile. When the bladder is viewed *in situ*, a single "red body" is seen to be present which is situated anteriorly in the ventral wall where the duct joins the bladder. A series of transverse sections shows that this "red body" is, as in the Eel, a large rete mirabile, which, however, is disposed in a different manner in the present instance. The artery and vein run along the right side of the bladder and break up to form the rete in such a manner that the long axis of this lies transversely to the length of the fish (Pl. II. fig. 9). The capillaries of the rete mirabile unite as usual to form larger vessels, which here, of course, lie to the left side of the bladder, where they break up anew to supply the epithelium of the gas gland. As in *Myrus*, there exists no sharp distinction between the glandular epithelium of the duct and that of the bladder, also the capillaries in connection with the epithelia are comparatively few in number. This epithelium consists, as in the two preceding genera, of a single layer of more or less columnar cells which occasionally becomes very slightly folded, but over the greater part of the wall, both of the bladder and the duct, the epithelium is a simple unfolded layer of columnar glandular cells. Strange to say, the cells of the epithelium of the bladder in my preparations are distinctly smaller than those of the duct. Occasionally large capillaries are present in the bladder wall, and where these occur the epithelial cells become, as in *Myrus*, almost squamous in shape. Small capillaries also exist, though they are not numerous. The epithelium of the duct remote from the bladder becomes much more squamous in character than elsewhere.

OPHICHTHYS (OPHISURUS) SERPENS L.

The general plan of the *two* retia mirabilia and the gas gland is exactly that found in *Anguilla*. The epithelial lining is, as in *Anguilla*, squamous and covers projections of the subjacent connective tissue, which contain, not one large capillary, but many small ones. Posteriorly the lumen of the duct, which anteriorly is circular in transverse section, becomes very restricted and star-shaped in outline, owing to the great size of the connective tissue projections just mentioned—a feature not met with in the species described above. The epithelium of the bladder wall is hardly folded at all over the greater part of its area, simply consisting of a single layer of short columnar glandular cells, but in places folding occurs, occasionally to such an extent as to resemble the bladder epithelium of *Anguilla*, but this is rare.

It is curious how the epithelial linings of the duct and bladder differ in these four closely related fish—*Anguilla*, *Myrus*, *Ophichthys imberbis*, and *O. serpens*. In the duct and bladder of *Anguilla* we have the extremes of flattened and folded epithelia; in the other genera intermediate conditions of the epithelium exist, both as regards the form of the cells and their arrangement, and the duct and bladder epithelia are not sharply distinguishable from each other, and yet the vascular supply has the same distribution in all cases, although it undoubtedly varies considerably in amount, being much greater in the Eel than in the other genera. The different conditions of the rete mirabile in the two species of *Ophichthys* are also noticeable.

The type of vasculo-glandular apparatus found in the bladders of the preceding genera may be defined as follows: the glandular epithelium is composed of a single layer of cells which either remains unfolded or is only simply folded, and the retia mirabilia are one or two in number and are large and distinctly separate from the gas gland, the capillaries of the rete reuniting to form large arteries and veins before coming into connection with the glandular epithelium.

*A Second Type of Bladder Vasculo-glandular Apparatus,
as exemplified in Syngnathus acus Mich.*

Syngnathus acus is a physoclistous fish in possession of a "red body," which is, on the whole, very similar in construction to that of the Eel, but which nevertheless exhibits certain differences which justify us in separating it as a distinct type. The "red body" in *Syngnathus* is visible with the naked eye as a small red patch at the extreme anterior end of the bladder. An artery and vein running in the anterior attachment of the bladder divide up in the manner already described for the Eel to form the single rete mirabile (Pls. II. & III. figs. 10–14). It will also be observed in figures 10 and 11 that posterior extensions of the diffuse pancreas (indicated in the figures by yellow masses) penetrate into the anterior end of the rete mirabile and, as will be shown in detail

later, are closely associated with the larger veins. Lying alongside the rete mirabile is the anterior extremity of the elongated closed bladder (fig. 14), the wall of the anterior region of which is very glandular and vascular. A little way behind the anterior extremity of the bladder, the side of the rete next the bladder comes into connection with the bladder epithelium (fig. 15), the capillaries uniting (*i. e.* the arterial capillaries are uniting and the venous capillaries are really here subdividing to form the minute venous capillaries of the rete) to form slightly larger vessels before supplying the epithelium of the gas gland. This process of supplying the glandular epithelium goes on until the whole of the rete mirabile is used up (Pl. III. figs. 15-17), the fine capillaries of the rete always uniting to some extent to form larger vessels before these supply the epithelium. The bladder epithelium, as shown in the figures, becomes enormously thickened by a process of folding during the breaking-up of the rete mirabile. Posterior to the rete mirabile, which has thus disappeared in supplying the glandular epithelium, this latter itself gradually dwindles (fig. 18) until in the posterior region of the bladder the cavity is lined with simple squamous non-glandular cells.

The epithelium of the bladder is quite simple in type and essentially resembles the folded epithelium of the Eel, though the folding is much more pronounced. Figure 19 represents the glandular epithelium in the unthickened region, that is, lining any side of the bladder cavity other than that adjacent to the rete mirabile, where, as just stated, the epithelium is much thickened. The folds of the epithelium due to the large capillaries which push out the epithelium are so deep that we have here, as in *Anguilla*, distinct ducts formed between the folds which contain on occasion large quantities of floccular matter evidently derived from the cells. The thickened epithelium adjacent to the rete mirabile is formed by the great extension of the folds just mentioned, the cells of which often join at intervals, *i. e.* the folds run together so that the at-first-separate ducts form anastomosing channels before opening into the bladder. The cells forming this epithelium are faintly granular and almost cubical in form, and here and there contain gas bubbles (not shown in the figure) and intracellular capillaries, but since I have examined these structures in greater detail in other types, I shall not refer to them any further at present. I shall also, and for the same reason, merely mention here the conspicuous opacity of the cytoplasm of the gland cells which comes into immediate contact with a capillary (fig. 19).

One other fact which is very well shown in my slides of *Syngnathus* remains to be mentioned, and that is the disintegration of the red blood corpuscles contained in the capillaries of the rete mirabile and the gas gland first into spherical globules and ultimately into granular matter. This granular matter resulting from erythrocytolysis is, of course, only found in the blood-stream and is to be carefully distinguished from the granular matter above described as being found in the bladder lumen and gland

ducts just external to the cells of the gas gland. Figure 21 (Pl. III.) shows several stages of this disintegration of the erythrocytes, the significance of which I shall discuss later.

Figure 20 represents a highly-magnified transverse section through the fine arterial and venous capillaries composing the mass of the rete mirabile. The two kinds of capillaries are quite indistinguishable by mere inspection. The capillaries are separated from each other by a small amount of connective tissue. In the very young fish, *i. e.* before the capillaries have subdivided to the extent found in the adult, the arterial capillaries are distinguishable from the venous, the former being thicker-walled and somewhat smaller in calibre (see also Bykowski & Nusbaum, 23).

Thus the chief features of the second or *Syngnathus* type of "red body" are that the glandular epithelium is arranged in simple folds, that it is restricted in area, not lining the whole of the bladder cavity, and that the rete mirabile is contiguous with the gas gland, although a small amount of reunion of the capillaries of the rete may occur before these supply the epithelium.

Other Examples of the Syngnathus Type of "Red Body."

GوبيUS NIGER.

As another example of the second or *Syngnathus* type of bladder vasculo-glandular apparatus I shall now describe that of *Gobius niger* caught at Naples*. The "red body" of *Gobius* is a small oval red patch situated just anterior to the centre of the oval outline of the bladder (Pl. III. fig. 22). It consists of a single rete mirabile which supplies a small area of glandular epithelium. As seen in a series of transverse sections, the artery and vein, which break up to form the rete, at first lie *outside the several layers of the bladder wall* (Pl. IV. fig. 23) together with large masses of pancreas. The artery and vein subdivide as usual to form a cluster of small arteries and veins, which in *Gobius*, as in *Syngnathus*, are intermingled with masses of pancreas (fig. 24). It will also be noticed that this cluster of arteries and veins is at this stage in process of *breaking through the thin dense outermost layer of the bladder wall*, so as to lie within this latter, large masses of pancreas being included with the cluster of vessels. Still more posteriorly when the arteries and veins have undergone subdivision to a greater extent, the whole mass of vessels together with the included portions of pancreas have become almost entirely *included within the bladder wall*, small portions of pancreas only being left outside (fig. 25). Finally, when the rete mirabile is completely formed it is wholly included within the substance of the bladder wall, as in previous genera (fig. 26). The rete mirabile supplies the adjacent area of glandular epithelium

* *Gobius paganellus*, obtained from Plymouth, possesses a star-shaped "red body" resembling that of *Peristethus* in construction (Pl. V. fig. 37, and text-fig. 57), though less definite in outline. *Gobius minutus*, also obtained from Plymouth, has a similar star-shaped "red body," but the gas gland epithelium in some specimens is hardly folded at all, merely consisting of a single layer of cells enclosing large capillaries; in others it is folded as in *Gobius niger* (Pl. IV. fig. 27).

in the usual way, the epithelium lining the rest of the bladder remaining squamous in character. It is, however, noticeable that in the rete of *Gobius* the fine capillaries do not unite together at all to form larger vessels before supplying the glandular epithelium (see fig. 27). In *Syngnathus* it has been mentioned that the reunion of the fine capillaries is very slight, but here it is quite absent.

The glandular epithelium is of the same type as that found in *Syngnathus*, the cells only, as may be seen from figure 27, being somewhat more columnar in form. The epithelial cells of *Gobius* are relatively large, and, as just stated, columnar in form and in my preparations faintly granular. They are folded in the simple manner already described for *Syngnathus* and *Anguilla*, large capillaries being situated in the interior of the folds*. In figure 27 are represented three epithelial folds of the gas gland, underlying which are a few of the multitudinous fine capillaries composing the rete mirabile. Even in this figure it can be observed that several of the cells contain spherical clear spaces and that two small capillaries have encroached on the space previously occupied by the cytoplasm of two cells of the gas gland. These intracellular bubbles and capillaries and the intracellular lumina, which I shall also shortly mention, are cytological features which have, within the last year or so, been studied in great detail by Jaeger (44-47), Bykowski & Nusbaum (24), and Reis & Nusbaum (54, 55, 62-66), and they are of considerable interest from several standpoints. I shall discuss their significance later; for the present I may remark that I think I am justified in redescribing these structures, especially in view of the controversy concerning the mode of gas-production considered in Part II. That the fine capillaries of the rete mirabile often find their way deep into the substance of the glandular cells, as well as between them, is proved in *Gobius* by a very moderate amount of inspection under a high power of the microscope (Pl. IV. figs. 28, 29). It is also noticeable that the protoplasm of that border of the glandular cells in contact with the capillary develops a dark and often striped appearance, which Nusbaum & Reis suggest is due to diffusion streams of nutritive matter passing from the blood into the gland-cells, but which I believe is intimately concerned with the production of the gas contained in the bladder (see Part II.). Concerning the presence of vacuolar spaces in the cytoplasm of the cells of the gas gland, nobody can doubt their existence who has examined well-preserved preparations of gas glands which are *in an active condition*. These vacuolar spaces are with good reason assumed to represent bubbles of gas being generated within the cell-substance (see Part II. and Appendix B), but it is evident that only on occasion will the gas gland be fixed and preserved when active; in the majority of cases, preparations of gas glands will not exhibit these intracellular gas bubbles, simply because the gas

* Reis (64) states that the folds branch and anastomose in *Gobius*; in all my preparations of *Gobius niger*, *Gobius paganellus* and *Gobius minutus* (also in *Gobius capito*—Coggi, 25) the folds are quite simple, as described in the text.

gland is normally quiescent*. To deny the existence of these cytoplasmic bubbles simply because certain microscopic preparations do not show them is illogical, to say the least, since intracellular gas bubbles, unlike intracellular capillaries, are not permanent but transitory structures. Of over fifty series of preparations which I have made of numerous types of gas gland, not more than seven or eight show these intracellular gas bubbles in an unmistakable manner. In the type of gas gland under consideration, one only of my six or seven series of preparations of the gas glands of different specimens of *Gobius niger* and *G. paganellus* exhibits a few gas bubbles (fig. 27). I have seen these bubbles best in a preparation of *Gobius minutus* (Pl. V. fig. 35), in which the gas gland cells were fixed in the active condition. As shown in figure 35, the majority of the gas-producing cells possess large vacuolar spaces in their cytoplasm usually present in the vicinity of the nucleus; indeed, the nucleus is often so adpressed as to assume a crescentic form. These vacuoles, which, as just mentioned, are assumed to represent the moulds, so to speak, which contained gas bubbles, just as liver- and kidney-cells exhibit similar vacuolar spaces which contained liquid globules (text-fig. 60, p. 225), are of various sizes, and some can be seen in the act of being ejected from the cell substance into the bladder lumen, where they are also occasionally found in a liberated condition (see Appendix B). The bursting of these gas bubbles is doubtless accountable for the masses of granular matter always found, when the gland is active, in the bladder lumen and gland ducts just external to the glandular epithelium, this granular matter, of course, having composed the walls of the bubbles. The gland cells, when active, always have that portion of their cytoplasm situated next vascular tissue very distinct from the rest, it being, as already described, very dense and often striated in appearance; the rest of the cytoplasm usually assumes a "stringy" appearance and is very vacuolate†. It may also be mentioned that the nucleus is not situated in the dense cytoplasm next the blood, in which respect gas gland cells show a marked difference from the cells of the pancreas, *e. g.*

In addition to intracellular capillaries and gas bubbles there are also occasionally to be seen intracellular lumina or ducts—continuations of the intercellular ducts into the substance of the gland cells. These, again, vary greatly in different types of gas gland and in different specimens of each type. In none of my preparations are they very numerous, and doubtless, like the gas bubbles, the smaller intracellular lumina are transitory structures. I have figured one or two of these structures in connection with the gas gland of *Ophidium barbatum*, a type very effectually studied by Reis & Nusbaum (62), and they are occasionally to be found in my preparations of *Gobius niger* and *Gobius paganellus* opening into the numerous finer intercellular ducts. Since these

* See Addenda (1).

† For excellent descriptions and figures of these gas bubbles in the cytoplasm of the gland cells, see the papers of Bykowski & Nusbaum (24) and Reis & Nusbaum (55, 62, 63).

intracellular channels have been so thoroughly studied by the authors just named, I shall not refer to them in any detail. I will merely say that since, according to Jaeger (47), gas glands are able, when active, to swell to three times their normal size, and that the finer ducts only become visible when filled with fluid, it is not surprising that they are only visible in very few preparations.

One or two other histological features to be observed in serial sections of the gas gland and associated structures of *Gobius niger* and other types remain to be mentioned. In transverse sections across the anterior end of the rete mirabile, and only at its anterior end, where the arteries are easily distinguishable from the veins, all the arteries possess a peculiar endothelium. This endothelium (Pl. IV. fig. 32) contains many more nuclei than usual, and these, instead of being flattened in the usual way, are more or less spherical, and, each being contained in a small mass of cytoplasm, project into the vascular lumen in the manner shown in the figure. This peculiar endothelium, in the case of the smaller arterial capillaries, results in such a thickening of the wall (and incidentally in some of the smallest capillaries a blocking-up of the lumen) as to cause the capillary to bear a strong resemblance to a bile- or pancreatic duct; indeed, were it not for the presence of blood corpuscles these small capillaries would be almost unrecognisable as such. This type of vascular epithelium, which must be well-known to histologists, in all probability results from the contraction of the pulsatile arteries in forcing the blood through the rete, the narrowed circumference of the endothelium causing the cells both to assume a globular form and to protrude into the lumen of the vessel.

Concerning the posterior extension of the diffuse pancreatic acini among the arteries and veins anterior to the formation of the rete mirabile (fig. 25, *e. g.*) there is little to note other than the fact itself, which I have not seen recorded by writers on the teleost pancreas (see list of references to pancreas literature below). When first studying teleost "red bodies" I was misled into supposing that this extraordinary extension of the pancreatic acini through and right into the bladder wall in many teleost genera represented a new gland specially developed in connection with the rete mirabile. I suggested (78) that the purpose of this supposed new gland was the abstraction from the venous blood stream of the globules and granules resulting from the breaking-up of the red blood corpuscles referred to above, and in my sections (stained by the picro-indigo-carminic method described in Appendix A) the zymogen granules present in the pancreas cells often strongly resemble erythrocyte globules which have been abstracted from the blood stream (*cf.* text-fig. 56 and Pl. III. fig. 21). Adopting the view of Jaeger (fully discussed in Part II.) that the cells of the gas gland produce a toxin for the purpose of breaking up the erythrocytes and so enable themselves to absorb more easily the oxygen in the blood stream which they subsequently pump into the gas bladder, I suggested that the purpose

of the rete mirabile—a structure essentially consisting of the intimate juxtaposition of the veins returning the blood from the gas gland and carrying the hypothetical toxin, with the arteries carrying freshly-oxygenated blood to the gas gland—was to allow the toxin in its venous capillaries to diffuse into its arterial capillaries and so to disintegrate the oxygen-laden erythrocytes in time for the oxygen to be available for abstraction by the gas gland cells by the time the arterial blood reached the gas gland. On this view the veins of the rete mirabile would be laden with granular matter (as indeed they are—see fig. 32) which requires to be eliminated, and I suggested that this process of elimination was the function of these pancreatic masses which are so closely connected with the veins at the anterior end of the rete—the kind

Text-fig. 56 (\times circ. 470).



Vein surrounded by modified acini (three shown) of the pancreas in *Nerophis æquorius*.

of vessels and the identical position that the hypothesis would suggest; in other words, the hypothesis was supported by the position of the gland, the modification of the pancreatic acini surrounding the veins (described below), the great similarity between the erythrocyte globules and granules in the blood, the zymogen granules in the pancreatic cells and the granules in the pancreatic ducts, and the *à priori* necessity for the elimination of the erythrocyte granular matter. This hypothesis, however, concerning the function of what I subsequently recognized as the pancreas is obviously untenable, since the zymogen granules are of course present in pancreatic cells not associated with the rete mirabile veins and, as in higher Vertebrates, do not occur outside the pancreas cells; also the posterior extension of the teleost

pancreas into the bladder wall cannot be supposed to be of any more significance than its penetration into the liver. I failed at first to recognize this gland as the pancreas, both because of its peculiar position inside the bladder wall and because of the peculiar modification of the pancreatic acini in juxtaposition with the veins, neither of which peculiarities have been described by writers on the teleost pancreas. Another small peculiarity existing in several teleost genera (*Gobius niger*, e. g.) which I studied more than others was the syncytial character of the wall of the pancreatic duct (Pl. V. fig. 33 and Pl. IV. fig. 34), a feature not present in most teleosts. The modification of the pancreatic acini in connection with the veins (veins from the rete mirabile as well as hepatic-portal veins from the gut wall) just referred to consists of the cells of each acinus next the thin vein wall being drawn out, the cells on the side remote from the vein being quite short, as shown in text-fig. 56. This figure also indicates the similarity between the zymogen granules and the erythrocyte globules, both globules and zymogen granules being stained a bright emerald-green in my preparations. As stated in Part II., I now have good reason to believe that the erythrocyte granular matter is abstracted from the blood in part by the liver and in part by special cell-masses situated near the kidneys. Laguesse (4-10), Rennie (17), and others have shown that the teleost pancreas resembles in all essentials the pancreas of higher Vertebrates—in the characters of the acini, ducts, zymogen granules, and the presence of centro-acinal cells and areas of Langerhans. With respect to these last, I may mention incidentally that I can fully confirm the results of Rennie (17) and there can be but little doubt now that these areas constitute an organ physiologically and in many teleosts anatomically distinct from the pancreatic acini. This view of the physiological independence of the islets of Langerhans is supported by the researches of Diamare (3), Flint (3a), Opie (14, 15), de Witt (2), Lane (11) and others in opposition to the view that the islets are patches of exhausted pancreas, supported by Lewaschew (12), Laguesse (6, 10), and Dale (1); and, as I have already remarked, researches on the teleost pancreas indicate quite plainly that the former is the correct view.

SIPHONOSTOMA TYPHLE (RONDELETHI Delar.), NEROPHIS
ÆQUORIUS.

The "red bodies" of these two genera are, like that of *Syngnathus*, small red patches situated at the extreme anterior end of the bladder and identical in their plan of construction. The only particular in which the "red body" of *Siphonostoma* differs from that of *Syngnathus* is that in the former the cells of the gas gland are much larger and the intervening ducts much narrower; indeed, in the posterior portion of the gland the lumina are so narrow as not to be seen very easily. The large capillaries are also more circular in transverse section in *Siphonostoma* than in *Syngnathus*. Gas bubbles and intracellular capillaries are in my preparations to be found occasionally in the substance of the

epithelial cells, also the cytoplasm in contact with the capillaries is darkened in the usual way. A small amount of granular material is present in the bladder lumen and gland ducts just external to the cells. I must also mention a peculiar class of corpuscles found in the blood of my specimen of *Siphonostoma typhle*. These peculiar corpuscles (Pl. V. fig. 36) possess very dense cytoplasm, are about half the size of the red corpuscles, and contain large nuclei. They are fairly numerous, forming roughly about 1 per cent. of the total number of corpuscles. They doubtless represent white corpuscles, though in my preparations they to some extent resemble small rounded ganglion cells; indeed, they bear quite a strong resemblance to the large dense ganglion cells so often found between the pancreatic acini, and are in consequence very conspicuous. I have not observed such conspicuous white corpuscles in the blood of any other of my preparations.

In *Nerophis* the gas gland epithelium is folded like that of *Gobius niger* and possesses the same features.

GASTEROSTEUS SPINACHIA.

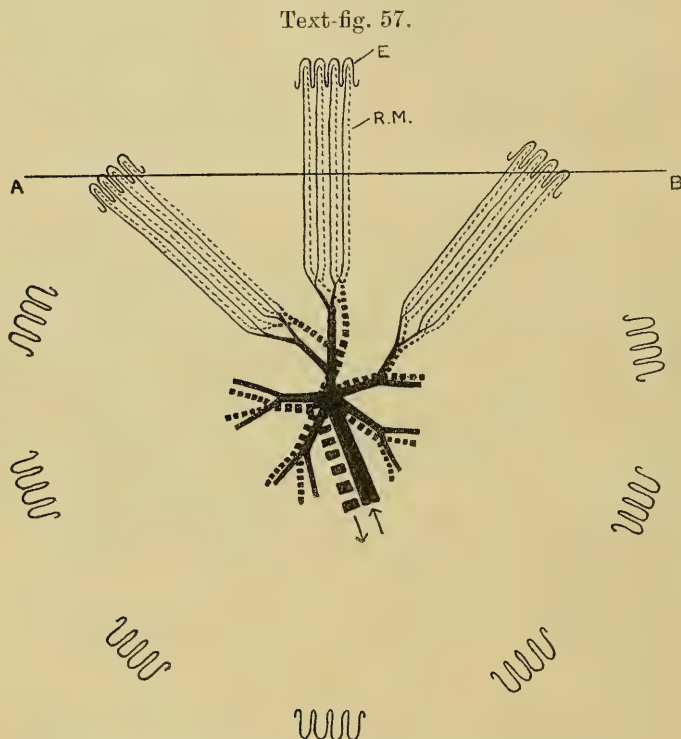
In this Stickleback the only feature in which the "red body" differs from those of the last four genera described is the splitting-up of the rete mirabile into three or four bunches supplying the gas gland epithelium at different levels; instead of the initial artery and vein wholly dividing up to form a single rete mirabile, an artery and a vein are given off from this to form a rete mirabile in connection with the most anterior region of the gland epithelium, another pair to form a second rete mirabile in connection with the middle region of the gland epithelium, and, finally, the initial artery and vein themselves form a third rete mirabile to supply the rest of the gas gland. This condition in *Gasterosteus* is intermediate between that described for *Syngnathus* and that about to be described for *Peristethus*. In all other respects the "red body" of *Gasterosteus* resembles the *Syngnathus* type.

PERISTETHUS CATAPHRACTUS (PERISTEDION · CATAPHRACTUM C. V.).

The "red body" of *Peristethus* is star-shaped (Pl. V. fig. 37), owing to the fact that the artery and vein which supply the glandular epithelium, when arriving at the centre of the star-shaped "red body," break up each into ten vessels. The score of vessels thus formed sort themselves out into pairs of vessels, each pair consisting of an artery and a vein. These pairs radiate out from the point of subdivision of the original artery and vein like the spokes of a wheel and give rise to ten elongated retia mirabilia in the manner shown in text-fig. 57. Each rete mirabile supplies a radially-disposed tract of glandular epithelium developed as usual from the innermost cellular layer of the bladder wall. The capillaries of each rete mirabile coalesce to a certain extent to form larger vessels before supplying the gas gland (not indicated in

text-fig. 57), but not to the same extent as in *Syngnathus*. Figure 38 (Pl. V.) represents a section (A-B in text-fig. 57) across the anterior end of the star-shaped "red body."

The epithelium of the gas gland is folded as in *Gobius niger*, but, as in *Syngnathus*, it becomes considerably thickened by the elongation and fusion of the folds in the vicinity of the rete mirabile. The cells are rather small and short-columnar in form, and, in the particular specimen which I examined, contained numerous gas bubbles (figs. 39, 40, 41); in other words, the gland was here in a highly active condition when preserved.



The construction of the "red body" of *Peristethus cataphractus*.

E., epithelium of gas gland; R.M., rete mirabile. Fig. 38 (Pl. V.) represents a section taken across A-B.

The most remarkable feature about the "red body" of *Peristethus* is, of course, the radial disposition of the divisions of the rete mirabile and the glandular epithelium; in every other respect it appertains to the *Syngnathus* type as above defined.

TRIGLA HIRUNDO (CORAX Bp.).

The bladder of *Trigla hirundo*, when observed from the ventral

aspect, appears as an elongated sac, the ventral wall of which is very muscular in the median line posteriorly. At the sides of this muscular posterior median portion of the bladder wall there are to be seen two red streaks, which are the lateral divisions of the "red body" (Pl. VI. fig. 42). In a series of transverse sections it can be seen that the cavity of the bladder has a peculiar conformation*: anteriorly the bladder cavity consists of two laterally-placed channels, which end blindly anteriorly and proceed posteriorly over a distance equal to about one-third the length of the bladder when each divides into two; these four channels thus formed then extend to about midway in the length of the bladder, when the two inner channels coalesce to form a wide median chamber, which, with the two external channels, extends to the posterior extremity of the bladder (Pl. V. fig. 43). It will be observed in figure 43 that two great median bands of muscle (M.B.) are developed in the ventral wall of the posterior half of the bladder; and this explains why it is that only the lateral "red bodies" are seen when the bladder is viewed from the ventral aspect (fig. 43). Also shown in this figure are the two laterally-placed strands (S) of nerve-fibres developed in connection with the two muscle-bands.

The epithelium of the gas gland is folded in the manner characteristic of this type of "red body," but in *Trigla* it is more folded than in previous examples (Pl. VI. fig. 44), the primary folds bearing small lateral folds. In some places the depth of the folding is increased as in *Syngnathus*. The cells are of moderate size and columnar in form. The rete mirabile is divided up into capillary tufts, *i. e.* there are numerous small retia mirabilia which supply the epithelium at intervals in its course; in other words, pairs of vessels are given off at intervals from the bladder artery and vein, each pair consisting of an artery and a vein and forming a rete mirabile to supply a certain area of gas gland.

TRIGLA GURNARDUS.

Concerning the gas gland epithelium of this species, see p. 207, below.

SMARIS MAURII, SMARIS VULGARIS.

The "red body" of *Smaris vulgaris* has the macroscopic appearance shown in figure 45 (Pl. VI.). Figure 46 (Pl. V.) represents diagrammatically a transverse section across the anterior end of the "red body," the primary artery and vein entering at the centre of the oval mass.

Concerning the character of the gas gland epithelium of these two species (Pl. VI. fig. 47), see p. 207, below.

Previously described "Red Bodies" of the Syngnathus Type.

The glandular epithelia of the "red bodies" of *Gobius capito*, *Trigla gurnardus* (see my description below), and *Gasterosteus*

* See description in Milne-Edwards (49).

aculeatus have been described and figured by Coggi (25); *Gasterosteus aculeatus* has also been described and figured by Deineka (29); *Bleinnius*, *Gobius*, *Syngnathus*, and other types have been briefly described by Reis (64). All these "red bodies" evidently belong to the *Syngnathus* type as defined above.

*A Third Type of Bladder Vasculo-glandular Apparatus,
as exemplified in Ophidium barbatum L.*

The "red body" of *Ophidium barbatum* has received a considerable amount of attention during the last few years, especially from the cytological standpoint (Bykowski & Nusbaum, 24 and Reis & Nusbaum, 62, 63), since the huge cells composing the gas gland offer exceptional facilities for enquiry in this direction. But, as in some other instances, good figures of the gross anatomy do not exist, so far as I am aware, and hence I shall make no apology for recapitulating already-known facts in a manner that shall be intelligible to the reader who has not worked at the subject.

The "red body" of *Ophidium barbatum* is situated anteriorly in the ventral wall of the bladder and has the curious appearance shown in figure 48 (Pl. VI.). The fan-shaped deep red portion is, of course, the rete mirabile, which is here an undivided body, and it is formed by an artery and vein which enter at the pointed posterior apex. The pink margin surrounding the anterior border of the rete is, obviously, the gas gland. A transverse section running midway through the "red body" exhibits the parts diagrammatically indicated in figure 49 (the outer layers of the bladder have been stripped off). In the centre is the rete mirabile and at the sides are the enormously thickened glandular portions of the (elsewhere) flattened lining epithelium. As in some former instances, there is no reunion of the capillaries of the rete mirabile before supplying the glandular epithelium: they directly supply the gas gland.

Now in this type of "red body" the gas gland does not consist of a single layer of cells which has become folded, but of a many-layered mass of cells, the arrangement of which bears no resemblance to the folded condition of the single-layered epithelium of the "red-bodies" already described (see figs. 54, 58, 63 for examples of the massive type of gland), and, judging from the development of this massive type of gas gland epithelium as seen in *Atherina*, it never does, at any stage of its development, bear a resemblance to the folded type of gland. The many-layered or massive kind of gas gland epithelium, as seen in *Ophidium*, *Atherina*, and other genera to be mentioned, is, then, a distinct type; the question raised by Reis in a recent paper (64) as to whether there exist forms of bladder epithelium transitional between these two types is one which I shall discuss when describing *Atherina*. The faintly-granular cells composing this many-layered gas gland of *Ophidium* are of quite moderate dimensions in the vicinity of the rete mirabile, but become larger the further they are removed, and the cells at the remote edge of the gland are remarkable for their large size. In this type of gland there exist

no large ducts comparable with those we have seen in the glands consisting of folded epithelium; on the contrary, the only ducts visible are narrow slit-like channels occasionally to be detected in their course between the cells. These narrow channels vary in width greatly according to the state of activity of the gland; they are necessarily numerous (though by no means always to be observed) in order to provide means of exit to the surface for all the numerous cells concerned, and they open on the gland surface inside the bladder lumen by small pores. Also penetrating the mass of the gland are numerous fine capillaries supplying the individual cells with nutriment and oxygen on the sides remote from those facing the ducts just mentioned. All the intracellular structures previously mentioned as occurring in connection with cells of the gas gland are here shown in a very obvious manner. Figure 50 (Pl. VI.) shows intracellular lumina, one in longitudinal section. As to the significance of these intracellular passages found in gas gland cells, it is not necessary to regard them all as possessing purely a nutritive utility as Nusbaum & Reis have supposed; it seems more probable, judging from their appearance in such cases as that illustrated in figure 50, that some at least are concerned with the passage of the gas bubble from the interior of the cell to the exterior; they are very rare in their occurrence in my preparations and in transverse section closely resemble bubbles, especially if near the nucleus. The whole mass of cells composing the gas gland is therefore penetrated by capillaries and gland lumina. I have not observed a pancreas in the region of the rete in *Ophidium*.

Other Examples of the Third or Ophidium Type of "Red Body."

BOX BOOPS L.

The "red body" of *Box loops* has the curious macroscopic appearance shown in figure 51 (Pl. VI.). Figure 52 (Pl. VII.) is a diagram of a transverse section through the middle of the "red body," and the appearance of two concentric loops is thus seen to be due to the disposition of the rete mirabile. The primary artery and vein enter the "red body" posteriorly and break up into smaller arteries and veins (intermingled with pancreatic acini) to form the rete mirabile as usual. The glandular epithelium consists, as in *Ophidium*, of a mass of cells interpenetrated by capillaries and lumina, but here the cells are all approximately equal in size and the gas gland is more than a dozen cells thick.

ATHERINA HEPSETUS L.

In macroscopic appearance the "red body" of *Atherina hepsetus* is diffuse in form (Pl. VI. fig. 53) and consists of tufts of retia mirabilia borne laterally on a median pair of vessels (artery and vein) with corresponding tracts of glandular epithelium. The glandular epithelium (Pl. VII. fig. 54) is very similar to that of *Box boops*; in other words, it consists in its thickest parts of a mass of small cells, seven or eight cells in thickness, with inter- and

occasional intra-cellular ducts and capillaries. I have not observed a pancreas in the region of the rete. The cell-outlines of the gas gland are faint and a small amount of granular material is present in the bladder lumen in my preparation.

I stated above that the massive type of gas gland is quite distinct from the folded type in certain genera, and, indeed, these two types of bladder epithelium are almost always easily distinguishable from each other in the genera which I have studied: genera, with a few exceptions to be mentioned, either possess the folded or the massive type of gland and not glands intermediate in structure. In young specimens of *Atherina* about 15 mm. in length, that portion of the bladder epithelium which is about to produce the gas gland is at first composed of a single layer of cubical or short columnar cells, and it is worthy of notice that these cells, in order to build up the fully-formed massive gland, all divide at right angles to the plane of the bladder wall (Pl. VII. fig. 55), *i.e.* the successive planes of cell-cleavage are parallel with the plane of the bladder wall—the initial unilaminar epithelium never becoming folded at any stage of development. As the gas gland cells multiply connective tissue cells may be observed to extend in between them in order to furnish the connective and vascular tissues which penetrate the mass of the gland when fully formed. Also if figures 54 and 55 be compared, it will be seen that the cells (especially the nuclei) of the gas gland of the adult *Atherina* are noticeably smaller as compared with those in the young fish. The fact that there is no indication of folding of the bladder epithelium during development of the massive type of gland is important, since Reis (64) supposes, on the ground that there exist forms of bladder epithelium more or less intermediate in structure between the folded and massive types, that the latter has been derived from the former, and if such be the case we might expect that the massive type of gland in its development would pass through a folded developmental stage. As we have seen, this is not the case in *Atherina* and presumably not in other genera possessing typically massive glands. I assume this with the more confidence since in some gas glands which, owing to the exceedingly close apposition of the folds, at first sight appear to be massive, it is always possible to refer them at once to the folded type by observing in each such case the margins of the gland where it merges into the squamous epithelium lining the greater part of the bladder cavity, since here the folds are quite simple: such marginal folds are never present in true massive glands.

Reis, in contending that the massive type of gland is but a derivative of the folded type, instances as transitional forms between the two types the gas gland epithelia of *Syngnathus* and *Girardinus*. I have not examined *Girardinus*, but the gas gland epithelium of my specimens of *Syngnathus* can certainly not be said to be transitional, since, as my description above of this epithelium clearly shows, the massiveness of the gland merely results from the extreme length of the folds and their occasional anastomosis:

the glandular epithelium is always unilaminar and the folds always clearly recognizable. My preparations do not at all confirm Reis's statement that the tubular outgrowths are so numerous at the base of the gland that they lose their lumina through mutual contact, and form almost complete layers of epithelial cells. On the other hand, the gas glands of some other genera which I have examined certainly do appear to be transitional in structure between the folded and massive types, viz. those of *Trigla gurnardus*, *Smaris maurii*, and *Smaris vulgaris*. I may say at once that in all three species, especially *Trigla gurnardus* and *Smaris maurii*, the gas gland shows distinct signs of being of the folded type, and in the two species just mentioned the folds are quite distinct and unmodified at the edges of the glands, but, on the other hand, the surface of the gland is covered by a continuous single layer of columnar epithelium (never present in the typical folded gland) and throughout the mass of the gland the cells at certain points lose their unilaminar arrangement*. In *Trigla gurnardus* †, and perhaps also in the other two species, the explanation of the superficial cell-layer seems to be that at the edges of the gland the unilaminar epithelium splits into two layers, the upper remaining unfolded and forming the superficial cell-layer and the lower becoming folded in the usual manner (text-fig. 58), the folds, however, anastomosing to a considerable extent and, as

Text-fig. 58.

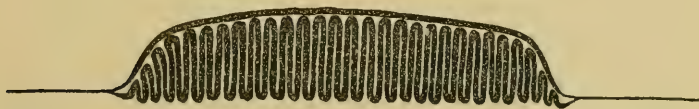


Diagram to explain the probable construction of the gas glands of
Trigla gurnardus and *Smaris maurii*.

already mentioned, the cells in places becoming clustered into groups more than one layer in thickness. In *Smaris maurii* (Pl. VI. fig. 47) the individual cells are larger than in *Trigla gurnardus* and the anastomosing folds more closely packed; here and there the cells are several layers thick, but in general they are arranged in single folded rows as in *Trigla gurnardus*. In *Smaris vulgaris* the epithelium has almost entirely lost its folded character, though this is sometimes to be detected at the edges of the gland. Thus the gas glands of these three species ‡ are to a certain extent

* In many massive glands the cells are often in places arranged in single rows, and this is evidently due to the necessity (which Oppel points out: see footnote on page 208) of each cell being in contact on one side with a duct and on the other with a blood vessel.

† Coggi (25) provides a figure of the epithelium of this species showing a simple folded character; the epithelium in my specimens more resembles his figure of the epithelium of *Motella mediterranea* with the addition of a superficial covering layer of columnar cells.

‡ And possibly those of *Polyacanthus* (*Macropodus*) described by Reis & Nusbaum (62) and *Motella* described by Coggi (25).

intermediate in character between the folded and massive types; but we may still retain these two categories, since we have reason to suppose that all of these three supposed transitional forms of gas gland really belong to the folded type and that they have only secondarily acquired features characteristic of the massive type by the splitting-off of a superficial cell-layer covering the surface of the gland, by close apposition and anastomosis of the elongated folds, and by occasional local proliferation of the cells; in other words, until their development is known, we may provisionally distinguish between truly or primarily massive glands which never exhibit the folded arrangement of cells at any stage of development, and pseudo- or secondarily-massive glands which are secondarily derived from the folded type*. To me Reis's suggestion that all massive glands have been derived from folded glands seems very improbable, since on this view the folded condition should occur as a stage in their development, and we have seen that this is not the case in at least one typical genus (*Atherina*). It seems more probable that both folded and massive types have originated independently from the simple unilaminar condition which must in all cases form the starting-point of development both in ontogeny and phylogeny.

CORIS JULIS † (VULGARIS Flem.).

The "red body" of *Coris julis* has the circular shape seen in figure 56 (Pl. VI.), and the rete mirabile supplying the gland is noteworthy for the way in which it is broken up into small divisions (Pl. VII. fig. 57). The glandular epithelium (fig. 58), which is

* Reis's classification of gas gland epithelia (64) seems to me confirmatory of this view. Her classification is as follows: (1) entirely unilaminar epithelium folded into simple tubular outpushings; (2) the epithelial folds are much folded and branched [Reis has made the mistake of including in this group the gas gland epithelium of *Corvina*; in my preparations of *Corvina nigra* the epithelium is of the most typical massive type]; (3) the epithelium is in parts folded and in parts multilaminar [I cannot agree to the inclusion of *Syngnathus* in this category. I have not examined Reis's other example—*Hippocampus*]; (4) the compact or massive glands of *Sargus*, *Charax*, and other genera. Reis regards these four types as a developmental series—a mistake I have corrected in the text. Reis also remarks that only in the first three types are the ducts obviously the spaces between the epithelial folds or tubular outgrowths; in the fourth there exist no such intertubular ducts, intercellular crack-like channels only being present. This last statement seems to me to be confirmatory of my contention.

Reis makes another statement which, as Oppel (58) points out, contravenes all probability. This statement is that whereas in the folded type of gland the individual gland cell only presents one surface towards the duct lumen (the others being contiguous with other cells and with a blood-vessel), in the massive gland the individual gland cell presents all its surfaces towards the intercellular lumina penetrating the mass of the gland, *i.e.* the intercellular lumina, according to Reis, surround each cell. Reis suggests that this supposed feature is for the purpose of facilitating the exit of the gas through the gland into the bladder. As Oppel justly remarks, how can a cell thus shut off from all vascular tissue obtain nourishment? So far as my observations go, there is no reason to suppose that a single cell of the massive gland is not in contact with a capillary. I cannot, however, agree with Oppel's groundless suggestion that tubular and massive glands possess different functions, tubular glands being secretory and massive absorptive. If this be so, from whence do fish with massive glands obtain their bladder oxygen?

† Mr. Tate Regan informs me that, according to Holt, "*Coris giofredi*" is merely the female form of *C. julis*.

about twelve cells deep, is an example of the massive type possessing a squamous lining epithelium. The lumina consist of small crack-like spaces visible here and there between the cells (largely arranged in vertical rows) in transverse sections of the gland, and they form a system of fine anastomosing channels opening at various points on the surface into the bladder lumen. Gas bubbles were occasionally to be found in the gland cells. I did not observe any intracellular capillaries, but they doubtless occur; intercellular capillaries, on the other hand, are extremely plentiful and occur largely near the extreme edge of the gland underlying the layer of flattened cells. The glandular epithelium of *Coris julis* differs from preceding examples of the massive type in that the cells lying next the bladder cavity form the squamous layer, or in places layers, just mentioned.

It was doubtless because Corning (28) chiefly examined "red bodies" of this extreme massive type, as *e. g.* that of the Pike, that he concluded that the bladder glands possess no lumina, and, indeed, were it not for our knowledge that most bladder glands possess lumina and that these vary greatly in volume according to the state of activity of the gland, we should probably come to the conclusion if studying exclusively the same material.

CORVINA NIGRA Cuv., SARGUS RONDELETHI C. V., BALISTES
CAPRISCUS L., CARANX TRACHURUS and SERRANUS CABRILLA L.

The "red bodies" of these genera all belong to the massive epithelium type, although they vary in appearance macroscopically (Pls. VII. & VIII. figs. 59-61) in correspondence with the varying configuration of the rete mirabile. The "red body" of *Balistes* alone is situated near the *posterior* end of the ventral wall of the bladder. In all cases the glandular epithelium has the usual structure—a thick mass of cells, penetrated by large or small intercellular and intracellular lumina and capillaries.

ZEUS FABER L.

The "red body" of *Zeus faber* is of the curious form depicted in figure 62 (Pl. VIII.), and occupies the anterior half of the ventral surface of the bladder wall. It has already been figured by Vincent & Barnes (75). The "red body" consists of two lateral divisions, each division being shaped like a **C** divided into three parts, and its concavity facing that of its companion. The primary artery and vein enter at about the centre of the "red body" and supply branches to the retia mirabilia lying on the inner sides of the gas gland thickenings. Anteriorly to the "red body" a thick median longitudinal muscle-band is developed in the ventral bladder wall. The glandular epithelium of the John Dory is of the ordinary massive type, though more folded in appearance than is usual. It is significant that Vincent & Barnes, who wished to reduce all "red body" glandular epithelia to the folded type, remark

that "we have not been able to obtain sections which show the direct transition to the tubular glands, but there is no doubt that the epithelium takes on fairly suddenly a markedly glandular aspect."

A conspicuous feature in the gas gland of *Zeus* is the presence, among cells of the ordinary size, of giant cells and nuclei six to ten times as large (Pl. IX, fig. 65). Similar giant cells also occur in *Ophidium barbatum*, *Pieraster acus*, *Peristethus cataphractus*, *Balistes caprisceus*, *Trigla gurnardus*, and, in some instances, in *Gobius paganellus* and in other genera. The only suggestion concerning the origin of these giant cells with which I am acquainted is that implied by Deimeka (29), who states that the similar giant cells in *Perca* give rise by *amitotic division of the nucleus* to groups of cells of the usual size—the implication being that the giant cells are primary products of development and cells of normal size secondary products. My observations have led me to a somewhat different conclusion. In the first place, in many gas glands containing giant cells (*Zeus*, e.g.), these giant cells usually lie more or less remote from the region where the blood-vessels enter the gland—giant cells are nearly always found towards the periphery or edge of the gland epithelium; secondly, there is every gradation in size from the smallest to the giant gas gland cells, the smallest always being situated in those portions of the gland next the large blood vessels, *i. e.* at the bases of the folds of folded glands and at the "hub" or point of entry of the blood-vessels in massive glands (see figs. 46, 49, 52, on Plates V., VI., VII. *e.g.*) in addition to other regions, the cells of intermediate size like the smallest cells being found in most regions of the gland and the giant cells, as already mentioned, towards the peripheral portions of the gland*; thirdly, among the smallest cells mitotic figures are quite common in many of my preparations, but among the intermediate and giant cells it is rare to find mitosis, though I have seen several cases of it in intermediate cells and once or twice even in cells approaching giant size; finally, I can confirm Deimeka in his statement that the great majority of giant cells and many intermediate cells divide amitotically. Figure 63 (Pl. VIII.) shows the appearance of the epithelium at the base of the gland of *Zeus*, where the capillaries of the rete enter. It will be observed that in this genus many of the basal portions of the massive epithelium are syncytial in character, no cell-outlines being distinguishable, and that occasionally mitotic figures are present among the nuclei of these syncytia. As we proceed from these syncytial masses towards the periphery of the gland, cell-outlines soon become more and more distinct and larger in size, but, as we might anticipate, though the giant cells are usually found towards the periphery of the gland, yet giant nuclei and nuclei of a size intermediate between these and the smallest nuclei are to be found

* Reis remarks that in *Sargus* (in which there are no giant cells) the cells are largest next the blood-vessels and decrease in size towards the periphery, where they are squamous in character. This is not the case in my preparations of *Sargus rondeletii*, where the cells are practically uniform in size at all depths of the gland, except perhaps at the very edge, where they are squamous.

in the syncytial masses at the base of the gland. In cells of intermediate size and in giant cells amitosis occurs, as I have already stated. Figure 64 illustrates several phases of direct division, but I must also mention that the huge nuclei of many giant cells, like those of myeloplaxes of bone-marrow, appear sometimes to divide into several—three, four, or more—nuclear lumps at a single division, though I do not remember to have seen cells containing more than two nuclei in the resting condition. These various facts considered collectively seem to suggest that in cases like *Zeus* the initial unilaminar epithelium of the bladder wall must contain nuclei of various sizes and that the nuclei of each size, associated with cytoplasm, multiply in order to produce the massive gland of the adult fish. As the nuclei become more numerous they migrate from the centre of proliferation, the small nuclei occupying cytoplasm which, owing to the size of the nuclei, becomes subdivided up into small areas, the larger nuclei, fewer in number, also occupying cytoplasm which, owing to the superior size of the nuclei and their slow rate of division, remains to a large extent unsubdivided, so forming the giant cells round the giant nuclei. There is no evidence in my preparations of giant cells splitting up into groups of small cells. The small cells multiply by mitotic division, and amitosis is only found in the case of the larger nuclei—those of the giant cells and larger intermediate cells. As to the origin of the giant nuclei I can give no information. It is stated that the cells of bone-marrow and some glands divide mitotically after undergoing amitosis, so that there is no theoretical objection to supposing that the small syncytial nuclei have been produced, as Deineka supposes, by amitotic subdivision of giant nuclei, but I have never seen any appearance of this taking place and I very much doubt its occurrence: nearly all the appearances of amitosis which I have observed have been in connection with the nuclei of giant cells, *i. e.* far away from the syncytia. As to the reason for amitosis occurring in connection with giant nuclei, it is only possible to readvance the old suggestion that it is a prelude to degeneration. The gas gland is in *Zeus* and presumably other types constantly being regenerated at its base, and therefore there is ground for supposing that cells at the periphery of the gland become used up and degeneration is the natural result of this. But this supposed degeneration of the cells has nothing to do with the violent decomposition of cell-substance assumed to occur by Nusbaum & Reis in connection with the production of gas—a phenomenon for the existence of which I can find no evidence and in which I quite disbelieve.

GADUS MORRHUA.

The "red body" of the Cod* is known to every student of comparative anatomy as a large red mass situated anteriorly in the bladder. As Vincent & Barnes (75) say, the free surface of the "red gland" shows "many small clubbed processes, packed

* I used common "Codling" caught off Deal.

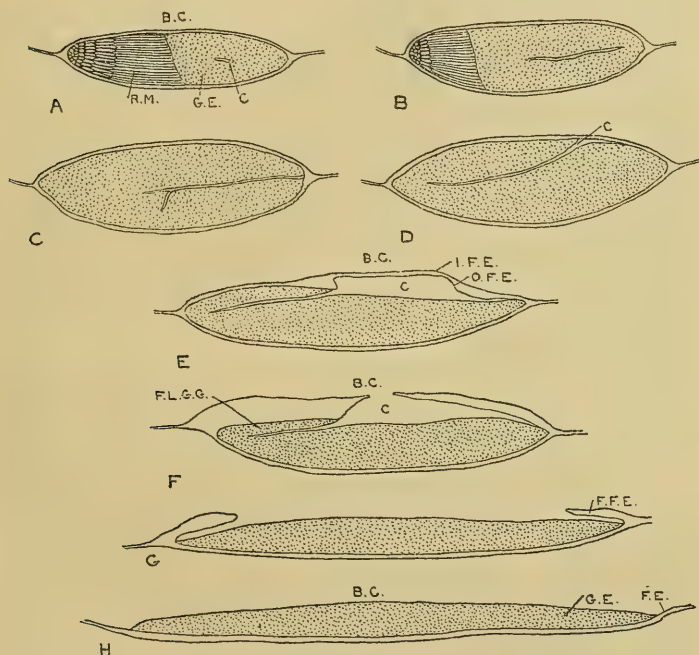
tightly together, each consisting of a red mass of tissue, surmounted by a cap of yellowish mucilaginous-looking material." Each club-shaped process "consists essentially of two parts:— (1) a mass of capillary blood-vessels, lying side by side, conveying blood to and taking blood from the second parts; (2) a glandular portion." In figure 66 (Pl. VIII.) is represented diagrammatically a transverse section of the gland of the "Codling," which shows the "clubbed processes" well in section, also one "cap of mucilaginous-looking" connective tissue. Vincent & Barnes go on to say that "when the capillaries arrive at a point about .2 mm. from the free surface of the gland, they interdigitate with involutions of the glandular epithelium, which dips down between them and forms a covering for them, thus constituting tubular glands .2 mm. in length." In other words, Vincent & Barnes state that the glandular epithelium of *Gadus* is that which I have described above for the Eel and *Syngnathus*, and they provide a diagram of what they suppose to be the folded arrangement of the epithelium. I am quite willing to admit that the small columnar cells which compose the glandular epithelium are in general arranged round strands of vascular connective tissue, and that occasionally the intercellular lumen is so extensive and so disposed as to give the glandular tissue an almost folded appearance, but there is no real ground for comparing the massive structure of the glandular epithelium of the "Codling" to the folded epithelium of *Syngnathus*. The gas gland of the "Codling" is of the massive type, in which the intercellular lumina are very abundant and occasionally very large. The capillaries are very small and run in the numerous thick strands of connective tissue. As Vincent & Barnes mention, caps of connective tissue, continuous with the connective tissue penetrating the glandular epithelium, are often present. I have not examined them in detail.

CEPOLA RUBESCENS L.

The "red body" of *Cepola rubescens* is situated anteriorly in the ventral wall of the bladder and has somewhat the shape of a bell (Pl. VIII. fig. 67), the handle being formed by the rete mirabile. The artery and vein enter the "red body" anteriorly at the top of the bell-handle, and there give rise to the rete mirabile in the usual way. The rete mirabile gradually diminishes as it supplies the mass of the gas gland, which first appears, in the series of transverse sections, on the right side of the "red body" (text-fig. 59, *G.E.*). The peculiar feature about the "red body" of *Cepola* is the curious folding of the glandular mass anteriorly. The gas gland extends a considerable way posteriorly, as seen in figure 67, and the best way to comprehend the folding anteriorly—the folding, that is to say, of the whole mass of the gas gland, not the folding of the epithelium hitherto described—is to observe the diagrams of the sections contained in text-figure 59 in the reverse order, *i. e.* observe H first and A last. Diagram H represents the glandular epithelium (the dotted area *G.E.*) as a mass of cells developed from the general squamous epithelium (*F.E.*) lining the

bladder cavity (*B.C.*) in the median line of the ventral wall of the bladder. In diagram G it is to be observed that the squamous epithelium on each side of the glandular mass has become folded (*F.F.E.*) and projects into the bladder cavity towards the median line. In diagram F these folds have nearly met in the middle line and lie dorsal to the gas gland in the bladder cavity; also it will be observed that on the left side the glandular mass itself has become completely reflected towards the median line (*F.L.G.G.*), and lies in close apposition with the rest of the glandular mass. Still more anteriorly, the two lateral folds of squamous epithelium have, as shown in diagram E, united in the median line, so that

Text-fig. 59.



Diagrammatic transverse sections through the anterior end of fig. 67 (Pl. VIII.), where the rete mirabile supplies the epithelium of the gas gland. The diagram is fully explained in the text.

two separate epithelia now lie in the bladder cavity above the gas gland, the upper of which (*I.F.E.*) is continuous with the squamous epithelium lining the rest of the bladder wall, and the lower (*O.F.E.*) is continuous with the two sides (the left reflected as just described) of the glandular mass, which latter therefore now forms the thickened ventral wall of a tube. Diagram D shows that the dorsal thin wall of the tube just mentioned is being replaced by extensions of the glandular mass, this replacement of the thin epithelium being chiefly due to the increase in size of the

reflected left side of the glandular mass. In diagram C the reflected left side of the gas gland has increased so as to extend over the opposite or right side of the gland, a narrow crack (continuous posteriorly with the bladder cavity) only being left between the dorsal and ventral halves of the gas gland. In diagrams B and A, owing to the coalescence of the glandular masses of the dorsal and ventral portions of the gas gland on the right side (*i. e.* the replacement of the short strip of thin epithelium which in C closed the tube on the right side), the narrow crack (C) becomes bounded on all sides by the glandular substance, and this crack narrows anteriorly until it disappears shortly before the gas gland itself terminates.

The mass of glandular epithelium (Pl. IX. fig. 68) resembles that of *Coris julis* in being (apparently) almost devoid of gland lumina. Small intercellular cracks are visible here and there between the cells in my preparations, but that is all to be observed in the inactive gland. On the other hand, the glandular mass is penetrated by capillaries, and the large cells appear to arrange themselves round these capillaries to some extent, giving the gland in section almost a lobulate appearance. The cytoplasm of the cells is conspicuously darkened where in contact with the capillaries. Now and again large cells are found with a very large nucleus, but these are rare. Finally, it may be mentioned that the capillaries of the rete mirabile possess the peculiar endothelium which I have already described in *Gobius paganellus* and found in most "red bodies."

PERCA FLUVIATILIS.

The "red body" of the freshwater Perch is a diffuse organ situated anteriorly on the ventral and lateral portions of the bladder wall (Pl. IX. fig. 69). The retia mirabilia are seen as small fan-shaped tufts present at the extremities of the various branchings of the closely-associated artery and vein (both included in the red streak seen in the bladder wall), and bordering these tufts of rete are the areas of gas gland. The gas gland is of the ordinary massive type, but feebly developed compared with the gas glands of most marine fish, consisting in its thickest parts of not more than six cell-layers (see text-fig. 62, p. 240) and dwindling to one at its edges (Pl. IX. fig. 70). The giant cells described by Deineka in young Perch are only of very moderate size in my preparations*, indeed, not so large as those I have figured in the case of *Zeus*; as in *Zeus*, amitosis occurs in connection with most of the cells. With reference to the suggestion of Deineka that these giant cells subdivide into groups of the smaller cells as a consequence of the fragmentation of the nucleus, I have already advanced reasons for regarding this as improbable (see *Zeus*).

Previous Descriptions of the Structure of the Ophidium or Third Type of "Red Body."

I shall here merely enumerate the chief histological descriptions of gas glands of the massive type. Emery 1880 (33), *Fierasfer*;

* My Perch were from 10-14 cm. in length.

Coggi 1886 (25), *Serranus*, *Perca*, *Balistes*, *Corvina*, *Julis*, *Motella* and other types, and 1889 (23) *Esox lucius*; Corning 1888 (28), *Esox*, *Perca* and other types; Vincent & Barnes 1896 (75), *Zeus*, *Gadus* and other types; de Seabra 1897 (31), *Esox* and others; Jaeger 1903 (44), *Sciaena*, *Lucioperca*; Deineka 1904 (29), *Perca*, *Esox* and other types; Bykowski & Nusbaum 1904 (24), *Fierasfer*, *Ophidium*; Reis & Nusbaum 1905, 1906 (62, 63), *Polyacanthus* (*Macropodus*), *Fierasfer*, *Ophidium*, *Charax*, *Perca*; Reis 1906 (64, 65), *Sargus*, *Charax*, *Pagellus*, *Corvina*, *Umbrina*, *Chrysophrys* and others described in a general way.

*Summary of Part I. and General Conclusions respecting
Gas Gland Structure.*

From the foregoing it is now manifest that all teleostean "red bodies," *i. e.* the vasculo-glandular gas-producing organs situated in the bladder wall, are composite structures consisting of two distinct and sometimes separate parts—the *glandular epithelium* or *gas gland** and the *rete mirabile*†. The mutual relationships of these two parts are quite constant, and though the gas gland must be described as the essential part, yet the rete, on account of its constant‡ presence and undoubtedly highly important function, is probably of almost equal importance. The rete mirabile bipolare geminum (Müller, 53), *i. e.* the arterial and venous rete already described, is always formed in connection with the artery and vein supplying the gas gland, and may either be anatomically quite distinct from the glandular epithelium (Eel type), the arterial and venous capillaries reuniting to a varying extent on the gland side of the rete to form large arteries and veins before supplying the glandular epithelium, or the rete mirabile may be contiguous with the glandular epithelium, the capillaries of the rete undergoing little (e. g. *Syngnathus*) or no (e. g. *Ophidium*) reunion before supplying this.

The diffuse pancreas, when present, is often intermingled with the arteries and veins situated at the extreme anterior end of the rete, and so actually becomes situated inside the bladder wall; it was at first, on account of several peculiarities, mistaken by me for a new gland with a special function connected with the gas gland, but this view was quite a mistaken one, the penetration of the pancreas into the bladder wall being of no physiological significance.

The gross anatomical differences, often visible to the naked eye, which are to be found in "red bodies" taken from different fishes, are determined by the disposition and degree of subdivision of the rete mirabile—since the distribution of the glandular

* The "drüsige säume" of Müller and the "corpo epitheliale" of Coggi.

† The "vaso-ganglion" of Owen and "organo vascolare" of Emery.

‡ That is to say, using the term "gas gland" in the usual sense as equivalent to "oxygen gland" (see Part II.), the rete is constantly associated with it; the rete, however, is absent in the cases of those bladders the lining-epithelia of which only, or principally, "secrete" nitrogen and carbon dioxide.

epithelium must evidently correspond with that of the rete mirabile. It need hardly be pointed out that the gross anatomical simplicity or complexity of the "red body" by no means always corresponds with the histological simplicity or complexity of the gland epithelium, and that this latter affords the only true basis for a classification of "red bodies." One of the most simple (though not the most primitive) conditions of the rete mirabile is when it is single and compact*. In this condition it may be separate from the glandular epithelium and ovoid in shape (*Ophichthys imberbis*, fig. 9, *e. g.*), or contiguous with the glandular epithelium and circular in form (*Gobius*, fig. 22, *e. g.*), conical (*Cepola*, fig. 67, *e. g.*) or fan-shaped (*Ophidium*, fig. 48, *e. g.*), &c. In some cases the rete mirabile is divided into two, and here these are separate from the glandular epithelium and ovoid in form (*Anguilla*, text-fig. 53, *Myrus*, *Muraena*, *Ophichthys serpens*, &c.). In other cases the rete mirabile is divided up into several distinct parts, which often have a radiate arrangement: *e. g.* in *Peristethus* the rete is split up into some ten radiating strands (fig. 37 and text-fig. 57) and in some species of *Gobius* into seven or more. In most cases, however, the initial artery and vein supplying the bladder give off numerous arteries and veins in pairs (an artery and a vein to each pair, of course) at intervals so as to give rise either (*a*) to continuous sheets of rete mirabile, so to speak, very often two in number, one on each side, as in *Corvina nigra* (fig. 59), *Sargus rondeletii* (fig. 60), and *Smaris vulgaris* (fig. 45), or (*b*) to sheets divided up in variable degrees, as *e. g.* in *Box boops*, where the sheets are divided into outer and inner on each side (figs. 51, 52), or in *Zeus faber*, where there are three separate sheets—anterior, median, and posterior—on each side (fig. 62), or (*c*) to numerous separate small strands or tufts of rete mirabile, each strand supplying a small area of glandular epithelium: thus, in *Coris julis* (figs. 56, 57) the rete is seen under the microscope to be subdivided into many small strands supplying the small area occupied by the gas gland; in *Trigla hirundo* also a similar condition exists, but here, indeed, the twigs extend nearly over the whole interior of the bladder cavity (fig. 43) instead of being restricted to a small area; in other cases where the tufts are larger and more separated, these can be seen with the naked eye, as, *e. g.*, in *Atherina hepsetus* (fig. 53) and *Perca* (fig. 69) and in the well-known case of the Cod (fig. 66), in which the subdivision of the rete mirabile reaches its maximum.

Whether the condition of the rete mirabile with which we started, *i. e.* as a single large well-defined body, separate from the

* Reis (64) supposes that the horseshoe-shaped gland of *Ophidium*, *e. g.* (see my fig. 48 and compare it with figs. 59, 60, and 62), is the form of gas gland and rete from which all others are derivable, but it seems to me that the simple oval rete of *Syngnathus* in connection with an extensive area of glandular epithelium, is still more simple; the most primitive condition of the epithelium and associated blood vessels is, of course, that of many freshwater teleosts in which practically the whole of the internal unilaminar lining-epithelium of the bladder constitutes the gas gland, and the arterial and venous capillaries have not become associated to form a rete. In general it may be said that the more diffuse the rete and gland the more primitive their nature.

glandular epithelium (*Ophichthys imberbis*, e. g.), is more primitive or more evolved than the condition which we found in the Cod, e. g., is a question I shall not discuss; I will merely say that there are several reasons for accepting, with de Seabra (31), the latter view. The fact that *Ophichthys* and *Anguilla* possess a very simple type of glandular epithelium is no objection to this view, since the rete of *Cepola* and other genera possessing complex types of epithelium is almost as simple.

The glandular epithelium, as we have seen, may line the whole interior of the bladder (as in many Anguilliformes and freshwater teleosts) or be restricted to a small area of the internal surface (*Ophidium* type). The *Syngnathus* type is more or less intermediate between these two conditions.

The character of the glandular epithelium varies greatly. The cells composing it may be arranged to form (a) a single unfolded layer (*Myrus*, e. g.); (b) a layer thrown into simple or complex folds, so that channels are formed leading from the surface of the glandular epithelium to the bladder lumen (*Anguilla*, *Gobius*, *Syngnathus*, *Trigla*, *Smaris*); (c) a thick mass in which the deeper cells can only communicate with the bladder lumen by a system of large or small anastomosing channels (the intercellular lumina) which penetrate the cell-mass and open into the bladder cavity by small apertures situated on the internal surface of the glandular mass (*Ophidium*, *Coris*, e. g.). At present neither embryology nor comparative anatomy provides evidence to justify the inference that this massive type of gland epithelium is in all cases derived from the folded condition—the folds on this view being supposed to have become elongated, laterally branched perhaps, closely apposed and fused at intervals to produce the cell-mass penetrated by narrow anastomosing channels. It would gratify me to be able to agree with Reis (64) who states that she is able to trace a complete developmental series of complications in the structure of the gas gland epithelium, the simple unfolded cell-layer forming the starting and the cell mass of *Coris*, *Cepola*, or *Esox* the culminating points of the series; but, as I have already stated, the available embryological and anatomical evidence suggests that the two complex types of folded and massive gas gland epithelia were separately derived from the primitive layer of glandular cells by folding (*i. e.* the plane of cell-cleavage is always at right angles to the plane of the bladder wall) and by thickening (the plane of cell-cleavage being parallel with the plane of the bladder wall) respectively. It is true that forms of gas gland epithelia occur apparently transitional in character between the folded and massive types (*Trigla gurnardus*, *Smaris maurii*, *S. vulgaris*), but I have supplied reasons for regarding these as glandular epithelia of the folded type which have become secondarily massive in form and so differing from the truly massive glands which never pass through a folded stage in their development. There is no reason, however, why certain glands should not be truly intermediate in structure, *i. e.* in which the cells during development divide simultaneously in planes both

perpendicular to and parallel with the plane of the bladder wall, but I know of no examples of such. Subsequent embryological enquiry can alone prove which of these views is the correct one.

The minute structure of the cells of the gas gland epithelium is doubtless constant throughout the entire series of "red bodies." Gas bubbles are in all cases generated in the interior of the cells (usually in the neighbourhood of the nucleus) when the glands are active, and these bubbles are ejected by the cells into the gland ducts and bladder cavity where they explode, the shattered walls of these bubbles giving rise to the masses of granular matter already described. Vincent & Barnes analysed this granular matter (which, as before mentioned, must be carefully distinguished from the disintegration products of the red blood corpuscles alone found in the blood-vessels) of the Cod and found it to consist principally of a nucleo-proteid; and since the cytoplasm which forms the wall of the gas bubble is also composed for the greater part of this substance, the result of this single analysis is confirmatory of the view just expressed, as is also the fact that a large amount of this granular matter is always associated with the presence of numerous gas bubbles. The intracellular ducts, which, with the other cytological features of the gas gland, have been so well figured by Bykowski & Nusbaum (24) and Reis & Nusbaum (62) within the last few years, are doubtless also constant features of active teleost gas glands, though I am of opinion that some of these intracellular channels are due to the expulsion of bubbles from the cells and not purely nutritive as Reis & Nusbaum suppose. The intracellular capillaries; on the other hand, are permanent structures, and the fact that they occur so rarely as compared with the enormous number of these structures found in connection with the liver cells can only be explained by the relative inactivity of the teleost gas gland.

I have already described and figured the hæmolytic disintegration of the red blood corpuscles (erythrocytolysis as it may be called) which occurs in the blood-vessels associated with the active gas gland of *Syngnathus acus*, and this same phenomenon is to be found in connection with other of my preparations of active gas glands and is doubtless a result of the gland's activity. In this process of hæmolysis many of the erythrocytes become entirely broken up, first into large globules and finally into the granular matter which is present in such large quantity in the capillary lumina, whilst others are distorted in shape and only partially broken up, looking very much as if influenced by some toxic substance, as Jæger suggests (see Part II.). This condition of the erythrocytes cannot be due to imperfect fixation since great care was exercised in the fixation and preservation of these gas glands; moreover sections through other vertebrates—Elasmobranchs *e. g.*—fixed by similar methods, exhibit the blood vessels as practically free from granular matter (the small amount sometimes present simply representing coagulated plasma) and the erythrocytes as retaining their form.

Another fact which I wish to lay stress upon, especially in view

of the theory advanced in Part II., is the distribution of the granular matter in the capillaries of the rete mirabile. Careful examination of my sections* of *Gobius niger*, *Gobius minutus*, *Syngnathus acus*, *Peristethus cataphractus*, *Gasterosteus spinachia*, and some others, in all of which the gas glands are more or less active, had led me to the conclusions that granular matter is present in the venous capillaries of the rete to a far greater extent than in the arterial, and that the relatively small amount of granular matter present in the arterial capillaries is chiefly situated next the distal pole of the rete—the pole next the gas gland. The small calibre of the arteries compared with the veins and the few series of sections of active glands, well fixed and well stained, which I possess render it difficult to be absolutely certain of the above conclusions, but I am as certain as the limitations of my material will permit me to be. The bearing of these facts on the theory already outlined on page 198 is perhaps already apparent, but I shall reserve discussion for Part II. (see p. 232).

As already implied, teleost gas glands are best classified according to the character of the glandular epithelium. We divide gas glands into two groups:—(1) gas glands in which the glandular epithelium is a single layer, which may either remain unfolded or become folded in variable degrees; and (2) gas glands in which the glandular epithelium is many-layered, the mass of cells being penetrated by fine ducts. With the exception of a few cases (*Trigla gurnardus*, *Smaris maurii*, *S. vulgaris*, and some others) in which the much-folded epithelium has secondarily assumed a massive character, this massive type of epithelium is probably not derivable from the folded type. Also in this second group of gas glands the rete mirabile is always contiguous with the glandular epithelium, reunion of the capillaries never occurring (*Ophidium*, *Fierasfer*, *Box*, *Atherina*, *Coris*, *Balistes*, *Sargus*, *Caranx*, *Charax*, *Serranus*, *Zeus*, *Gadus*, *Cepola*, *Esox*, *Perca*, &c.).

Group 1 is subdivisible into two minor groups:—

- (a) The rete mirabile of the gas gland consists of either one or two bodies distinctly separate from the glandular epithelium, the capillaries of the rete reuniting to form large arteries and veins before they come into connection with the glandular epithelium (*Anguilla*, *Myrus*, *Ophichthys*, *Murcena*, &c.).
- (b) The rete mirabile of the gas gland is contiguous with the glandular epithelium, although a small amount of reunion of the capillaries occasionally occurs (*Syngnathus*, *Gobius*, *Siphonostoma*, *Nerophis*, *Gasterosteus*, *Peristethus*, *Trigla*, &c.).

In concluding this account of the practical work connected with

* Observations of the rete mirabile, when sectioned longitudinally, are preferable from this standpoint; the arterioles are, of course, distinguishable from the venules by thicker walls, by small calibre, and by the peculiar endothelium before mentioned

the present paper, I wish to express my great indebtedness to the Council of King's College, London, for generously allotting me the sum of thirty pounds out of the Government grant to the College for 1907 to defray a part of the expenses incurred by me during my visit to the Naples Zoological Station in April of that year. I wish also to express my indebtedness to the Naples Zoological Station Table Committee of the British Association for the occupancy of the table at Naples during the three weeks just referred to, and to the staff of the Naples Zoological Station for the large amount of trouble they took in supplying me with the material I required in connection with this and other subjects. Further, I wish to thank Professor A. Dendy, F.R.S., and Professor S. J. Hickson, F.R.S., for kind recommendations in connection with the above-mentioned grant and occupancy of the Naples table respectively, Professor J. P. Hill, D.Sc., and Dr. G. C. Chubb for recent friendly assistance, Mr. C. Tate Regan, M.A., for kindly advising me in connection with the systematic nomenclature adopted in this paper (the nomenclature of Günther's Catalogue), and Mr. C. Biddulph, who has considerably lightened the burden of preparing some hundreds of slides. Finally, I am also much indebted to the Council of the Royal Microscopical Society for kind permission to occupy their table at the Plymouth Marine Biological Laboratory during a week in August, 1909.

PART II.—A FEW SUGGESTIONS CONCERNING THE PHYSIOLOGY OF THE "RED BODIES."

It was my original intention to include in Part II. of this paper a *résumé* of our present knowledge of the physiology of the gas bladder*, but although, with this end in view, I have become thoroughly acquainted with the whole of the vast literature dealing with the subject, yet other work prohibits me at present from thus devoting the time necessary for the composition of such a review. This being the case, I shall content myself with providing an outline sketch of the chief views which have hitherto been advanced to explain the mode of working of the "red bodies," in order that the reader may be in a position to estimate the value of the few additional suggestions I have to make.

The several views which have been held concerning the origin of the three† principal gases—oxygen, nitrogen and carbon dioxide—contained in variable proportions in the gas-bladder cavity, can be classified into two categories: (1) the view (first attributed to Redi) that these gases are derived directly from the atmosphere, and (2) the views (lineal descendants of Needham's secretion theory‡) that these gases are derived more or less

* A recent account of the functions of the bladder will be found in Baglioni (18).

† Argon is also stated to occur in the bladder.

‡ It should be noted that authors in discussing the production of gas employ the term "secrete" in a very loose manner, some thereby meaning a true process of secretion, such as that which occurs in the sebaceous gland (Nusbaum & Reis, *c. g.*), others (Hüfner, Jaeger) merely meaning a process of pumping from the blood.

directly from the blood stream. The first view, abandoned by nearly all modern authors, is, however, persistently maintained by Thilo (70, 71, 72). Thilo's principal contention, stated briefly, is that the blood of a fish is not sufficient in quantity to contain the amount of gas found in the bladder, and that even if this were the case the circulation of the fish is so feeble that the blood could not replenish an emptied bladder in the time experiment proves that it can be replenished. He therefore asserts that in all cases the bladder-gas must have been procured by the fish directly from the atmosphere: Physostomi can always renew their bladder-gas by rising to the surface of the water and passing air along the ductus pneumaticus, whilst Physoclisti are apparently under the hard necessity of absorbing a sufficient supply when young, and therefore before the duct has degenerated, to last them throughout life, though Thilo further maintains that in many cases even adult Physoclisti are still able to procure fresh supplies by passing air, either swallowed from the atmosphere or extracted in some inexplicable manner from the water, along the strand of tissue representing the vestigial duct. Thilo performed experiments and, according to his statements, obtained results which strongly support his view. He asserts, *e. g.* that he cut off the vascular supply of the previously-emptied bladder in *Tinca* (a physostome) and that in thirty hours it became refilled with gas. Seeing that the blood-supply was absent, he argues that this fresh supply of gas must have been obtained from the atmosphere by passage through the pneumatic duct. I, however, cannot find that he analysed the gas produced under these conditions, and, since atmospheric air and secreted gas nearly always consist of oxygen, nitrogen and carbon dioxide associated in very different proportions in the two cases, his contention as to the source of the gas receives very little real support from his experiments. A few of the many obvious objections to Thilo's hypothesis may be stated. In the first place, the percentage composition of the three gases contained in the bladder is, as just mentioned, quite different from that present in the atmosphere, and in the cases of oxygen and nitrogen these gases are often present in such quantities as to exert a pressure many times greater than the pressures they exert in air—both of which elementary facts are fatal to Thilo's view. Thilo's contention that the blood of a fish with its feeble circulation is incapable of providing the quantity of gas required by the bladder of course begs the question at issue, and he might with equal force contend that the tissues of a siliceous sponge, for example, must be incompetent to deposit a massive siliceous skeleton, seeing that 100,000 parts of sea-water contain little more than one part of silica in solution and that diatoms and other minute organisms are serious competitors even for this small quantity (Sollas). Further, Thilo's experimental results are not in accordance with those obtained by Hüfner (38), Jaeger (45), and others, and, indeed, Thilo's own experiments failed to render his contention even probable since the gland cells of the bladder would not necessarily cease their activity immediately a large

part of their blood-supply was cut off. It is also certain that most physostomous fishes do not obtain their gases from the atmosphere *via* the pneumatic duct, since the pneumatic duct is now known to be merely one of the two principal mechanisms (the other being the "oval") employed by fish for the elimination and not the obtainment of gas. Finally, Thilo's theory fails to account both for the degeneration of the ductus pneumaticus in Physoclisti (since, according to Thilo, it is still functional) and for the presence of the complex "red bodies" which are the very structures needed by the fish on account of the feeble blood-circulation referred to by Thilo.

Theories which derive the bladder gases from the blood stream can again be grouped into two classes, viz. those which suppose that the blood gives up its gaseous constituents more or less directly to the bladder, the gas passing straight from the capillaries of the rete mirabile, or wall of the bladder, into the bladder lumen, and those which regard the gas gland as the special organ which extracts the gas from the blood. The first class of opinions, to some extent associated with the name of Moreau, is now quite out of date, though still to be found stated in some recent text-books. The second class of opinions comprises two quite distinct views as to the exact function of the gas gland—two views which at the present time are held with equal tenacity by the schools represented by Jaeger and Nushbaum & Reis respectively. I shall first state briefly the view of Jaeger (44-48).

Jaeger, following Hufner (38), holds that the gas gland is primarily a pumping apparatus, that is to say, an apparatus for pumping the gases contained in the blood into the bladder cavity. The pressure exerted by the gases in the blood is, of course, considerably less than that exerted by the gases in the bladder*, and it is the function of the gas gland to force the gas from the blood into the bladder lumen against this superior pressure. Jaeger further supposes that the disintegration of a certain percentage of red blood corpuscles is effected by the secretion on the part of the gas gland cells of a toxin which is poured into the blood for this purpose. The object of so breaking up the erythrocytes is to enable the gas gland cells, in some way not described, to lay hold of, with greater facility, the oxygen thus scattered in the corpuscle fragments. Indeed, Jaeger, following Moreau, regards the gas gland as a mechanism essentially concerned with the pumping of oxygen—as an oxygen gland, in short,—a view confirmed both by the great development of this gland and by the disintegration of the erythrocytes in connection with bladders containing a large percentage of oxygen, and also by the contrary fact that in the bladders of Cyprinoids and many other freshwater fish which mostly contain nitrogen, the gas glands are absent—the ordinary squamous epithelial lining here being capable, without undergoing any special modification into a

* E. g. Jaeger (46) states that in deep-sea fish the partial pressure of the oxygen in the blood only amounts to about one-fifth of an atmosphere, whereas the oxygen in the bladder may possess a partial pressure of over forty atmospheres.

gland, of pumping in the nitrogen alone required. The reason for the special development of the oxygen gland in many deep-water fishes* is because oxygen alone among the gases present in the bladder is capable (in virtue of its property of combining in large quantity with the hæmoglobin of the blood) of being either rapidly produced (by the gas gland) or rapidly absorbed (by the "oval"†), and this rapidity of production and absorption is essential in the case of fishes which undergo considerable changes of pressure in the bladder. Deep-water marine or freshwater fish differ from most freshwater fish in that living in great depths of water those possessing migratory habits in a vertical direction require apparatus for adapting the volume of gas in the bladder to the violent changes of pressure experienced; most freshwater fish, on the other hand, live in comparatively shallow water—in inland lakes and rivers—and thus lead placid lives, experiencing little or no changes of pressure in the bladder, and for these fish it is evident that there is no need for the special development of an oxygen gland, which makes extravagant use of the gas which the fish requires for respiration: nitrogen and carbon dioxide suffice‡. With reference to the spherical spaces present in the cells of the gas gland, Jaeger altogether denies that they represent gas bubbles: they are merely vacuoles such as are to be found in liver-cells, *e. g.* and have no connection with the production of gas. Jaeger himself, however, describes gas bubbles as being present in the ducts of the gas gland. Jaeger also refuses to admit that the large amount of granular matter found outside active glands in the bladder lumen is the product of the gas gland cells: in short, represents the broken-down walls of exploded gas bubbles. I shall discuss these features of Jaeger's theory later.

Nusbaum & Reis (54, 55, 62–66), relying upon their extensive investigations of the cytology of the gas gland, formulate certain peculiar views§ as to the exact mode of function of the gas gland. Jaeger, as already stated, holds with Hüfner that the gas gland is essentially a pumping apparatus, though he confesses entire ignorance as to exactly how the individual gas-producing cell

* Only those deep-water fishes which migrate vertically and thus experience differences of pressure; fish which remain at one depth, however great, obviously have no more need for "red bodies" than have surface fish (see p. 228).

† Any sort of gas can, of course, be eliminated by the pneumatic duct.

‡ Mlle. C. M. L. Popta in her recent paper entitled "Étude sur la Vessie Aérienne des Poissons" (Ann. Sci. Nat. Zool., t. xii, 1910, pp. 1–160) comes to the conclusion that "la vessie aérienne des poissons se développe pour aider à la circulation de l'oxygène [et en général des gaz] dans le corps du poisson." I confess that this conclusion does not convey much meaning to me. I entirely fail to understand why the fish should develop an organ for the sole purpose of liberating oxygen into the blood in the same way I suppose that the liver liberates food material, and this is the only intelligible proposition which the author's conclusion conveys to me. Though the bladder undoubtedly in many cases performs this function incidentally, yet the fact that the bladder often contains other gases (nitrogen and carbon dioxide) the presence of which in the blood cannot be of the slightest advantage to the animal, shows that this storage function of the bladder cannot be its primary function. I cannot see that the author's conclusion in any way explains the different proportions in which the three principal gases occur in the bladder.

§ Unfortunately adopted in the last edition of Wiedersheim's 'Vergleichende Anatomie der Wirbelthiere,' Siebente Auflage, 1909.

extracts the gas from the blood and forces it against great pressure into the bladder: the supposition is, on his view, simply a legitimate deduction from the facts, and the details of the process, upon which he can throw no light, are of secondary importance. Nusbaum & Reis, on the other hand, profess to have discovered in the cytology of the gas gland cell, some details of the process which prove that the gas gland is not the mere pump which Jaeger assumes it to be. The view of Nusbaum & Reis is briefly this:—Examination of the cells of the gas gland proves the existence of spherical spaces in the cytoplasm which are not mere vacuoles as Jaeger assumed, but represent actual gas bubbles being formed in the cell. These gas bubbles are also to be found in the act of being ejected from the cells, and also lying freely in the gland ducts and bladder lumen, Jaeger himself necessarily agreeing that they are bubbles when found outside the cells, since liquid vacuoles could not possibly so persist. Thus much is a matter of observation, but Nusbaum & Reis contend, in explanation of these facts, that these bubbles of gas are produced by the actual decomposition of the substance of the gas gland cells, just as gases are produced by putrefaction, and in proof of this cell-decomposition they describe the actual breaking-up of the cells—the nuclei* fragmenting in the manner described by Deinekka for the Perch and the cytoplasm becoming converted into the masses of granular matter found in the gland ducts and bladder lumen. The principal reason which leads Nusbaum & Reis to this surprising conclusion is the supposed incompetence of the blood to supply the percentage of nitrogen gas found in the bladder. Among minor features of this hypothesis of Nusbaum & Reis, we may mention that they regard the disintegration of the red blood corpuscles both as a source of nutrition for the gas gland cells (the granular striping of the borders of gland cells in contact with capillaries and the intracellular channels penetrating the gland-cells being evidence of the cells absorbing this nutrition) and as a source of the oxygen which, with the nutrition, is urgently required by the cells in connection with their rapid decomposition.

Thus the respective views of Jaeger and Nusbaum & Reis largely differ as regards the function attributed to the individual gas gland cell. Jaeger regards it as essentially a pumping mechanism; Nusbaum & Reis regard it as, primarily, mere substance to be decomposed into its gaseous and solid constituents, both being extruded into the bladder.

I will now proceed to discuss these two views as a preliminary to a statement of my own views on the subject. Apart from omissions common to both theories, which I shall endeavour to remedy shortly, the chief fault to be found with the theory of Jaeger is his refusal to recognize the origin of the gas bubbles in the cells of the gas gland. Concerning the existence of these

* I may point out in this connection that during hæmolysis the nucleus of the red corpuscles appears to persist quite unchanged, even though the cytoplasm may become entirely disintegrated.

structures there can be no doubt whatever (see Appendix B). They have been exhaustively studied by Bykowski and Nusbaum & Reis, and I have myself described and figured them in the present paper. Jaeger himself, as I have already stated, admits the presence of vacuoles in the gas gland cells, but, curiously enough, denies that they contain gas, and pronounces them similar in nature to the vacuoles in the cells of the liver. It is difficult to understand why this comparison should be made, since, from his own standpoint, it is the function of the gas gland cells to pump out gas and not to store up glycogen or fat. But even adopting his suggestion that the supposed gas bubbles are only vacuoles, we may remark that several authorities have described in the kidney "the formation of vesicles in the cells and appearances which indicate the discharge of these vesicles into the cavity of the tubules" (37); and since kidney cells, like the gas gland cells, are supposed by many modern physiologists to derive most of their excreted substance by direct abstraction from the blood, comparatively few of the constituents of urine being

Text-fig. 60 ($\times 1000$).



Vacuoles in the kidney cells of *Nerophis*, some apparently being expelled into the lumen of the tubule.

manufactured in the cell, we may certainly conclude that even liquid vacuoles can be originated and discharged in a manner precisely comparable with that of the gas bubbles, and that if they contained gas instead of liquid they would be indistinguishable. I have figured some of the vacuoles present in the kidney cells of the fish *Nerophis* (text-fig. 60). It is evident that in histological preparations no sign of the liquid urine would be visible after expulsion from the cell, whereas the gas bubble with its walls of cytoplasmic material may, like a soap bubble in air, persist for some time before bursting. Consistently with his denial of the gaseous nature of the vacuoles in the gas cells, Jaeger was compelled to regard the granular masses lying external to the gas gland in the bladder lumen merely as a bye-product of the specific activity of the gas gland.

If, however, we fully agree with Nusbaum & Reis as to the

origin of gas as bubbles in the cytoplasm of the gas gland cells, we as certainly disagree with the interpretation they put upon this phenomenon, viz. that the gas is produced as the result of the actual chemical decomposition of the cytoplasm. Like Jaeger we have found no evidence of that peculiar cell-disintegration which is supposed by Nusbaum & Reis to be the histological expression of the chemical decomposition of the cell. It is true, as Jaeger admits, that in the cells of active gas glands the cytoplasm (not the nucleus, which remains normal) often assumes a "hard-worked" appearance—the cytoplasm looks "stringy" and contains numerous empty spaces—and considering that the process of continuous pumping of gas into the bladder must be exceedingly arduous, this is not surprising. It is also true, though not admitted by Jaeger, that the expulsion of bubbles from the cell into the bladder involves, to a considerable extent, waste of cell-substance. Each bubble, as already mentioned, possesses a wall of cytoplasm, and on the bursting of the bubble in the bladder lumen or gland duct, this wall, of course, breaks down and contributes to the mass of granular matter found in the bladder lumen and gland ducts. It must be confessed, therefore, that cell-disintegration occurs to a considerable extent and is associated with the production of bubbles of gas, but this mechanical disintegration of cell-substance is quite another thing from the hypothetical chemical decomposition of cell-substance postulated by Nusbaum & Reis (see Appendix B). Jaeger criticises this hypothesis of Nusbaum & Reis in a very effectual manner. He first of all points out that it is impossible to regard the epithelium of the gas gland as analogous in its mode of working to a sebaceous gland, since the cells of the sebaceous gland decompose in order to produce a highly-complex substance chemically different from the substances supplied to them by the blood, whereas the cells of the gas gland give rise to the most simple of substances, viz. the gaseous elements oxygen and nitrogen which are supplied to them ready-made. In other words, the production of oxygen and nitrogen, unlike the secretion of the sebaceous gland, requires no elaborate cell-metabolism, and there is therefore no reason for the gas gland cell-decomposition which Nusbaum & Reis affirm*. Further, according to Nusbaum & Reis, the blood corpuscles in breaking up supply the gas gland cells with oxygen for the decomposition of their substance, from

* We may, indeed, compare the process of gas-production with another process familiar to the present writer, in which a simple substance is also supplied to the cell and again liberated by that cell though in a different form, viz. the deposition of calcareous spicules in various invertebrate groups. Calcareous spicules have, like gas bubbles, been regarded by some investigators as resulting from the actual transformation of cell-substance, but this view is not held by any modern zoologist. The spicule-secreting cell is now regarded as a mechanism for abstracting the dissolved calcareous matter from the sea-water and of redepositing it, mixed with a variable minute amount of organic substance, in a crystalline form, the aggregate of calcite crystals constituting the spicule. The work of the cell in this case is simply the abstraction and recrystallization of the dissolved calcareous salts—there is no question of cell-decomposition. The mode of working of the kidney cell may also be compared in this connection.

which decomposition oxygen is to be produced (!), but oxygen cannot be used up in decomposing the gland cells and yet be available to fill the bladder space. And as regards the supposed production of free nitrogen by the decomposition of the gas gland cells, Jaeger might have pointed out that such a fact would be unique in animal metabolism. Free nitrogen is not known to be liberated by any katabolic process. The only source of the free nitrogen found in the bladder must be the small amount of that gas dissolved in the blood plasma. But Jaeger's chief objection to the theory of Nusbaum & Reis is the impossibility of accounting for the high pressure of the gas contained in the bladder, if this gas be simply produced by the decomposition of the cell-substance. The generation of carbon dioxide from chalk at once ceases, he points out, despite a high temperature, if the gas be allowed to accumulate in the calcination chamber, and in the same way the decomposition of cytoplasm would cease long before the liberated gas could exert a fraction of the pressure usually found in the bladder*. Oppel (57), in a summary of papers by Reis & Nusbaum, also objects that whilst these authors strongly insist upon cell-degeneration yet they have not stated in what way the epithelium is regenerated after periods of activity, and I also have been unable to come to a conclusion as to the opinion held by Reis & Nusbaum on this subject. In one paper (62) these authors state in the last two sentences that they have observed mitotic figures in the gland cells, and conclude that regeneration of the gland is effected by ordinary cell-division; in a subsequent paper (63), however, they appear to embrace the curious view that the amitosis first described by Deineka in *Perca* is a result of the violent cell-decomposition associated, in their opinion, with the activity of the gas gland, *i. e.* the nuclei, as well as the cytoplasm, undergo disruptive changes, and that this amitosis (55) leads to the production of new cells which take the place of those broken up! Needless to say, I fail to see any justification for this phoenix-like theory. My own researches have proved that the cells of the gas gland, when worn out like other cells of the body by a long period of activity, are replaced by ordinary mitotic divisions of the small cells at the base of the gland and that amitosis is only found in the later cell-generations. I may also mention in connection with this necrobiotic or decomposition theory of Nusbaum & Reis that, apart from other objections, it has always seemed to me to expect too much from the individual cell of the gas gland. The cell is not only required to commit suicide by undergoing decomposition but whilst undergoing decomposition it is to work energetically† in pumping the results of its own decay into the bladder cavity. Even the cell of the

* This particular objection of Jaeger is invalid since the decomposition of cytoplasm, being irreversible, would not be inhibited by pressure.

† "The formation of the gas bubbles in the cells is accompanied by fragmentation of the nucleus and simultaneous granular disintegration of the cell-plasma. . . . Condensation of the gas [in the cell] must accompany its formation since the lumen of the bladder is filled with gas at a considerable pressure." Translation of Reis (64).

sebaceous gland is not called upon for this degree of self-sacrifice. Finally, the researches of Deineka (29) on the intimate nerve-supply of the cells of the gas gland—it being stated that each gland cell is surrounded by a terminal cluster of nerve-filaments—and the known nervous control of the gas gland by two kinds of fibres running in the vagus and sympathetic nerves respectively (Moreau, 50, 51, 52; Bohr, 20; and others) render it very improbable that such cells undergo the wasteful decomposition assumed by Nusbaum & Reis.

I have now discussed the main features of the rival theories of Jaeger and Nusbaum & Reis. If we eliminate the errors and combine the truths of both with some observations of other authorities, we arrive at the following outline statement of the mode of working of the gas gland. The gas gland, in some unexplained manner, but probably, as Jaeger suggests, by the secretion of a toxin (which Reis & Nusbaum suggest he should have figured!) so influences the blood conveyed to it as to cause the disintegration of a certain proportion of red blood corpuscles. This fact of the disintegration is admitted by Bykowski and Nusbaum & Reis. The disintegration of the erythrocytes is primarily for the purpose of enabling the gas gland cells to “lay hold” of the relatively large quantity of oxygen contained in the blood. Oxygen, in consequence of its easy obtainment from the blood, is the all-important gas required by fishes which undergo considerable and rapid changes of pressure in their bladder consequent on rapid changes in their vertical position, and the gas gland, considered as a special development of the lining epithelium of the bladder, is solely concerned with the rapid production of oxygen. The gas gland being essentially an oxygen gland is therefore most developed in those fishes which possess the greatest proportion of oxygen in their bladder gas; in fishes like the Cyprinidæ and some other freshwater families, on the other hand—fishes which exist in inland waters possessing little depth and which cannot, therefore, experience great changes of pressure in their bladder by vertical displacement,—nitrogen and carbon dioxide form the principal constituents of the bladder gas* and gas glands, in the ordinary sense of the word, and retia mirabilia are absent. It was formerly supposed that a large proportion of oxygen in the bladder was associated with the great depth at which the fish existed—the greater the depth the greater the percentage of oxygen,—but apparently this is not altogether the case†. A large proportion of oxygen, as already stated, seems to be, for the most part, associated with the habits of those fish which frequently make considerable excursions in a vertical direction: if the fish sinks, the oxygen gland becomes active and

* *Cyprinus carpio* contains about 94 per cent. of nitrogen in its bladder (Hüfner).

† Cf. *Exocoetus volitans*, the Flying-fish, an essentially surface marine form, possessing, according to Humboldt (41), 94 per cent. of nitrogen in its bladder, with *Coregonus acronius*, a freshwater form living permanently at a depth of over seventy metres and possessing, according to Hüfner, about the same percentage of nitrogen, and many other examples might be quoted.

rapidly produces oxygen in considerable quantity in order to counteract the compression of the bladder due to the increased pressure and so to maintain the equality of the specific gravity of the fish with its medium; if the fish rises, either the absorption-organ known as the "oval" comes into action and returns the surplus oxygen in the swollen bladder to the blood, or, if the fish be a physostome, the pneumatic duct allows the surplus gas to escape to the exterior. Between the two extreme classes of bladder—the oxygen-filled bladder with "red bodies" and the nitrogen-filled bladder devoid of "red bodies"—there exist many transitional kinds containing a relatively small percentage of oxygen and feebly-developed "red bodies"*. As regards the exact mode of abstraction by the gas gland of the gases contained in the blood and their subsequent expulsion into the bladder, papers already published afford little or no information on the subject. In the case of those gases present in the bladder in minute quantities, it is probable that they leave the blood by simple diffusion: *e. g.* Traube-Mengarini (73, 74) and Priefer (60) showed that this was the case when hydrogen was dissolved in the water†. It is evident, therefore, that the problem of gas-abstraction becomes of importance only when the partial pressure of any particular gas in the bladder exceeds that in the blood. That the gas gland cells act as a pump is certain‡; it is also certain that the gases first enter the cells in a dissolved condition and that, just as a scleroblast converts dissolved calcareous salts into a solid spicule, so the gas gland cells cause these dissolved gases to appear in a gaseous form as bubbles in the cytoplasm§. In addition to this, however, the gland cells subject these gas bubbles to a considerable pressure, greater than that existing in the bladder, so that when the gas bubbles are expelled into the bladder lumen and experience a diminution of pressure they burst. As regards the varying composition of the bladder gas, it can only be concluded that the cells of the gas gland, like the cells of the kidney, exercise a selective power. That the oxygen pumped into the bladder is derived from the blood no one doubts, but Nusbaum & Reis, Thilo, and some others find a great difficulty in supposing that nitrogen (and carbon dioxide) is

* *E. g.* *Perca fluviatilis* contains on an average 15 per cent. of oxygen, 83 of nitrogen, and 2 of carbon dioxide (Hüfner); *Lota vulgaris* 65 per cent. oxygen, 30 nitrogen, 5 carbon dioxide (Hüfner), &c., &c. For analyses of the bladder gases in many fish see the works of Biot (19), Configliachi (27), Delaroche (30), Humboldt & Provençal (39, 40), Hüfner (38), Richard (67) among others. The percentage composition of the bladder gas exhibits, as might be expected, considerable variation not only in different individuals of the same species of fish but in the same individual at different times.

† It must be mentioned, however, that Humboldt & Provençal (39) in 1809 performed this experiment of impregnating water with hydrogen and failed to detect a trace of hydrogen in the bladder, but probably their methods of analysis were too crude.

‡ In this connection Hüfner ventures to compare the gas gland cells with the contractile gland cells described by Drasch (32) in the neck-skin of the Frog, both being similarly supplied with nerves.

§ *Cf.* the gas vacuoles in *Arcella* and other Thecamoebida.

similarly derived. It is true that the amount of nitrogen dissolved in the blood is very minute as compared with the amount of oxygen, but, on the other hand, nitrogen does not, like oxygen, require to be produced at a rapid rate; and since the supposition of Nusbaum & Reis, that free nitrogen is generated by the decomposition of cell-substance, is quite inadmissible for the reasons supplied above, the nitrogen dissolved in the blood can be the only source of that gas. It is well known that human blood, when suddenly released from great pressure, develops bubbles of nitrogen owing to the inability of the blood to re-dissolve the gas immediately, and doubtless the cells of the gas gland also so act upon (though certainly not by a diminution of pressure) the blood plasma bathing their substance as to compel the nitrogen to assume a gaseous form. Once abstracted from the blood stream, the nitrogen, in the case of those bladders containing nitrogen at high pressure, is pumped in the same way as, and in many cases with, the oxygen into the bladder lumen*.

I now propose to offer some additional suggestions concerning the physiology of the gas gland which have occurred to me during the course of my work. It is curious that not one of the investigators mentioned in the foregoing pages has attempted to explain in a satisfactory manner the striking conformation of the rete mirabile. A year ago I published in a short note (78) (based, as I have already explained, upon a mistaken conception of the teleost pancreas) a sketch of a new theory concerning the use of the rete which I have again outlined on a preceding page of this paper, but apart from this I have met with no suggestion concerning the physiological significance of the rete mirabile bipolare geminum (or more simply rete mirabile duplex)†. I now propose to restate more fully this theory of mine, but before doing so I will mention the only previous hypothesis of which I am aware. Johannes Müller (53) stated that in his opinion the retia mirabilia associated with the gas glands of teleost fishes (and Müller was one of the first, if not the first, to distinguish the gas glands—"Luftdrüsen"—from the retia mirabilia and to state their proper function as gas-producers) possessed the same utility as the various other kinds of retia mirabilia described by him, viz. to cause the blood stream to flow more slowly for some physiological purpose, and this opinion has been adopted, so far as I know, by all subsequent observers. Presumably the slowness of the blood stream in connection with the gas glands is supposed to be for the purpose of allowing the cells of the gas gland time in which to abstract the gases present in the blood, and that this is one function of the rete mirabile I myself do

* Haldane (36) comes to the same conclusion.

† The following suggestion concerning the use of the duplex rete associated with the gas glands may throw some light upon the physiology of the similar duplex retia mirabilia which are stated to occur in connection with other structures, e. g. the "choroid gland" associated with the eye of many teleosts and the rete in connection with the liver of the Tunny.

not doubt.* But this explanation does not, in my opinion, explain all the facts, since, if mere slowing down of the blood current is the one desideratum, then a rete solely connected with the bladder artery is all-sufficient. Further, it is evident that the explanation takes no account either of the fact that the bladder vein also forms a rete mirabile or of the still more remarkable fact that *the retia on the bladder artery and vein respectively are both formed at exactly the same distance from the gas gland and their constituent arterioles and venules as intimately intermingled as any product of human manufacture purposely so designed could be.* The suggestion which I venture to offer as to the use of this complex arterial and venous rete universally associated with gas glands is the natural conclusion of the following considerations. The fact that some hundreds of the finest capillaries conveying blood to the gas gland are intimately intermingled with and closely apposed to a like number (another significant fact) of similar capillaries conveying blood *from* the gas gland is suggestive of the exchange between the two sets of capillaries of some substance necessarily of importance to the gas gland with which the rete is connected. This hypothetical substance we must assume both to be diffused from the venous capillaries to the arterial (since diffusion in an opposite direction would not affect the gas gland) and to be derived from the gas gland. The question which next arises is why this hypothetical substance should be poured into the arterial blood before it reaches the gas gland, and the only answer that suggests itself is that it is necessary for this substance to influence the arterial blood in some manner during its passage (made slower by the rete) from the rete to the gas gland, so that by the time the arterial blood reaches its destination, its constitution has become altered. Now I have already stated that the gas gland, in the limited sense of the term, is essentially an oxygen-producing gland and that therefore the oxygen contained in the blood is the one element which the gas gland requires, from which fact we may conclude that the hypothetical substance referred to has something to do with the giving up of oxygen by the blood to the gland. In the foregoing lines I have mentioned that such a hypothetical substance has already been postulated by Jaeger to explain the disintegration of the red blood corpuscles. We may therefore state as extremely probable suppositions that in the rete the venous capillaries contain a relatively large quantity of a toxin poured into the blood by the cells of the gas gland, that this toxin diffuses from the venous capillaries into the arterial, and that whilst the arterial blood is slowly travelling from the

* This function, however, cannot be exercised in the case of the retia mirabilia of the Eel, which are separated from the gas gland by a relatively few large vessels, since the reunion of the arterial capillaries on the side next the gas gland means of course the quickening of the blood stream. Neither can the Eel's rete mirabile possess the supposed function of the "carotid gland" of Amphibia, of "deadening" the heart pulse, since the gill capillary system of the fish must effectively eliminate all trace of this; on the other hand, the rete mirabile must certainly minimize the pressure of the blood supplying the gas gland, a result which, in the present instance, we must regard as a defect.

rete to the gland the toxin effects by a process of hæmolytic the partial or total disintegration of a certain proportion of erythrocytes, the cytoplasm and oxyhæmoglobin pigment of each being scattered in the plasma, the former giving rise to the masses of granular matter so largely present in the blood returned from the bladder and the latter becoming dissolved in the plasma.

Is there any evidence of this process actually taking place? In reply to this question I am able to cite one fact, already stated on page 219 in Part I., which I think constitutes strong evidence in the affirmative. It is evident that if this process takes place then we may expect to find at the proximal pole of the rete, *i. e.* the pole remote from the gas gland, large quantities of granular matter (resulting from the erythrocytolysis above described) present in the venous capillaries but little or none in the arterial, and that towards the distal pole of the rete (the toxin, on the hypothesis, having had time to diffuse from the venous capillaries and influence the arterial blood) granular debris will also appear in the arteries. Careful examination of the rete mirabile associated with active glands has convinced me that this inferred distribution of the granular matter in the rete capillaries is a fact. Figure 32 (Pl. IV.) represents a section taken across the proximal pole of the rete and shows the absence of the erythrocytolytic granules in the arteries; a section across the distal end of the rete, on the other hand, shows that hæmolytic of the arterial blood has commenced, erythrocytolytic granules being present.

Oppel (56) puts a question which will be asked by many other critics of the foregoing theory of "red body" physiology. Why, he asks, is it at all necessary for the erythrocytes to be broken up in order that oxygen may be supplied to the cells of the gas gland? In other words, if, as we know is the case, the blood readily gives up its oxygen to supply the ordinary tissues of the body, where is the necessity for the manufacture of a special toxic substance in order to effect this same liberation of oxygen in the case of the gas gland? I am not aware that Jaeger or any other author has given a definite answer to this question, but a consideration of the facts will soon supply one. In the first place, it is evident that the cells of the gas gland stand in a very different relation to the oxygen of the blood as compared with that of ordinary tissue cells, since whereas the latter are deficient in oxygen and require it solely for purposes of metabolism, the former are already saturated with oxygen and only lay hold of it in order to concentrate it and pump it into the bladder; in other words, the cells of the gas gland require to get a very effectual "grip" on the oxygen which the tissue cells do not*. Secondly, realization of the conditions obtaining in the normal supply of oxygen by the blood to the tissues will enable us to understand the necessity for a toxin. The combination of oxygen with the hæmoglobin

* This necessity for the gas gland cells to be in the closest contact with the blood is possibly accountable for the presence of the intracellular capillaries already described, perhaps also for the intracellular lumina as conveyors of exuded plasma into the cell-substance. The same phenomena are met with in the cells of the liver—an organ which also requires close contact with the blood—, the canaliculi representing the intracellular channels.

pigment contained in the red corpuscles is, as is well known, a very loose one, and this loose combination is, according to modern views, only maintained by the maximum partial pressure exerted by the small amount of oxygen dissolved in the blood plasma. Further, it is important to notice in connection with the present subject that in the liberation of oxygen to the tissues of the body, it is the oxygen dissolved in the plasma which is immediately supplied to the tissues, and not the oxygen associated with the hæmoglobin. The oxygen of the oxyhæmoglobin compound only becomes liberated as a consequence of the lowering of the partial pressure of the plasma oxygen caused by tissue absorption and when liberated merely serves to replenish the plasma and is not conveyed directly to the tissues, so that the plasma with its limited solvent action on oxygen must be recognized as the all-important intermediary between the store of oxygen combined with the hæmoglobin and the tissues. Now in the case of the cells of the gas gland, already employed in pumping oxygen into the bladder and certainly possessing all and more than they require for metabolic purposes, it is difficult to imagine that they can absorb the oxygen dissolved in the plasma in the manner employed by ordinary tissue cells. Even if they are so able, the small amount of oxygen so obtainable is quite insufficient for their purposes, since the oxygen, unlike the nitrogen and carbon dioxide, is required to be rapidly produced in large quantities. The only alternative is, then, for the gas gland cells to seize upon the main source of the oxygen, viz. the oxyhæmoglobin, and so obtain in wholesale quantity what the plasma can only supply in retail*. This is effected, as we have seen, by the production of a toxin which, doubtless by a process of hæmolysis, breaks up the red corpuscles into fragments and so liberates the contained oxyhæmoglobin into the plasma, the rete ensuring that this hæmolysis and consequent solution of oxyhæmoglobin in the plasma is effected in time for the dissolved pigment to be available

* This reduction of the blood to the primitive invertebrate condition in which the respiratory pigment is dissolved in the general plasma and not imprisoned in elastic discs (the erythrocytes) as in Vertebrates raises the question as to why, if the former condition enables the tissues to absorb the oxygen more readily, the latter condition has arisen. Apart from a few lamellibranch and other Mollusca and a few Polychætes and *Phoronis* in which hamatids have been described, all Invertebrates (and, according to Lankester, also Amphioxus and the *Leptocephalus* larva of the Eel, but hamatids have been stated to occur in the former and possibly exist in small number in the latter) carry the respiratory pigment, when this is present (absent in the tracheate Arthropods, *e. g.*), in the plasma, and it is difficult to understand what advantage accrues from preventing the dissolved oxyhæmoglobin coming into direct contact with the tissues in vertebrate animals. It is of course possible that the indirect distribution of oxygen by way of solution in the plasma conduces to a more even and gradual supply to the tissues, especially in animals like Vertebrates in which most of the tissues are very remote from the limited respiratory area of the body surface; in most Invertebrates, on the other hand, oxidation of the blood takes place over most of the body surface and the tissues are all practically simultaneously reached by the blood which, being contained in sinusoids rather than in capillaries, bathes them on all sides. The more rapid circulation of the blood and larger quantity of hæmoglobin in Vertebrates possibly compensate for the absence of hæmoglobin in the plasma. As is well known, when hæmoglobin is liberated into the plasma in Vertebrate blood, it is at once eliminated by the liver and kidneys. See Addenda (2).

for absorption when the blood reaches the gas gland. Is there any evidence that the cells of the gas gland absorb this oxyhæmoglobin dissolved in the blood plasma? It is not too much to say in reply that every preparation of a gas gland in at all an active condition does provide very substantial evidence as to the actual occurrence of this process. In every such preparation (see figs. 28-31, 50, 68, 73, *e. g.*) it is at once noticeable that the cytoplasm of the gas gland cells in contact with the capillaries—and usually the cells are only separated from the blood by the thin endothelium—is of dense appearance and forms a perivascular zone quite distinct from the rest of the cell-protoplasm, a feature which has been described and figured by all recent observers of gas gland structure—Jaeger, Bykowski, Nusbaum, Reis and the present writer (see Part I.). Nusbaum & Reis hold that this appearance of the cytoplasm next the blood vessels is merely evidence of absorption from the blood of the nutritious matter afforded by the disintegration of the erythrocytes, but for the reasons just given we prefer to believe that the oxygen associated with the hæmoglobin is *the* desideratum of the gland cells and that whatever nutritive value ingested fragments of stroma may possess is quite a minor matter. However, the opinion of Nusbaum & Reis is of value in supporting our conclusion that the cells of the gas gland do actually absorb from the blood material liberated by the breaking-up of the erythrocytes. Examination of good preparations of active glands shows that this darkening of the cytoplasm of the individual gas gland cell situated next the blood-channel really possesses a striped appearance (Pl. IX. fig. 73)—Bykowski & Nusbaum, *e. g.*, describe it as “die charakterische Streifung des Protoplasmas rings um die Blutgefäße”—similar to that seen at the edges of the cells lining portions of the gut, in the Sertoli cells of the testis and in other cases, and this striping found in so many kinds of cells is proof of a process of absorption taking place. We do not suppose that the fragments of corpuscle substance composing the granular matter in the blood stream are absorbed by the gas gland cells, but only the oxyhæmoglobin dissolved in the plasma, and the fact, which we have previously stated, that the veins of the rete mirabile are in active glands full of this granular matter is in accordance with this view. It can thus be proved by what practically amounts to actual demonstration that the cells of the gas gland do absorb the dissolved oxyhæmoglobin directly from the blood (see Addenda (3)), and the natural inference is that this is employed for the supply of oxygen to the bladder.

Judging from analogies provided by other classes of secreting cells, what possibly happens in the metabolism of the gas gland cell in the production of bubbles of oxygen gas from the absorbed oxyhæmoglobin dissolved in the blood plasma is that at that end or pole of the gas gland cell situated next the blood stream the dissolved oxyhæmoglobin forms a loose combination with the cytoplasm, this combination being merely a temporary linkage of the molecules of the two substances (similar, *e. g.*, to the linkage of

side-chains forming "anti-bodies," which Ehrlich assumes to occur in his theory of immunity) and that later at the remote pole of the cell, *i. e.* the region of the cell remote from the blood stream, this loose temporary incorporation of the dissolved oxyhæmoglobin with the cytoplasm breaks down with the liberation of oxygen gas, which, as already seen, arises as bubbles usually in the vicinity of the nucleus. The slight decomposition of cell-substance which we may thus suppose to occur is evidently quite distinct from that decomposition postulated by Nusbaum & Reis. In our supposition the temporary linkage of the oxyhæmoglobin with the cytoplasm is merely to enable the cytoplasm to obtain a "grip" on the oxyhæmoglobin in order to dissociate the oxygen; in the supposition of Nusbaum & Reis it is the cytoplasm itself which decomposes.

A minor point remains to be mentioned. We have already stated that the veins returning the blood from the gas gland contain a relatively large amount of granular matter resulting from the hæmolysis of the red blood corpuscles, and the question remains as to what becomes of this superfluous granular matter. It can only be said in reply that probably a large portion of this disintegration material is eliminated from the blood by the liver, since we know that one function of the liver cells in all Vertebrates is to destroy degenerate corpuscles* and other waste material in the blood; possibly also the spleen assists in this connection, though, judging from its histological appearance, I doubt it. I have also observed in several genera (*Nerophis*, *Gobius*, *Gasterosteus*, &c.) masses of cells lying to the outer sides of or between the kidneys in which a destruction of effete blood-corpuscles seems to be actively proceeding. It is, however, of little concern to us in what manner the blood is clarified in these teleostean fishes; it suffices to say that the relative purity of the arterial blood in the bladder proves that such elimination does take place.

On reviewing the foregoing pages it will be seen that the hypothesis concerning the physiology of the "red bodies" just elaborated has much to be said for it. In its essential features it is the theory of Jaeger and Hüfner, supplemented, however, and in some respects corrected, by the observations of Bykowski, Nusbaum, Reis, and other investigators, and slightly extended by the few suggestions made by the present writer. Its validity is assured by the number of diverse facts which it interprets, for not only does it explain the general fact of the existence of the "red body" as the only mechanism possible under the conditions for the rapid inflation of the bladder, but it also explains the minutest details of this mechanism, such as the perivascular striping of the component cells of the gas gland and the disintegration of the erythrocytes, and such a wide range of interpretation constitutes the criterion of a true theory.

* These erythrocytes in the liver have of course been largely deprived of their oxygen by the gut tissues.

APPENDIX A.

The Sources and Modes of Preparation of Material.

A great part of my material was obtained by me during my occupation of the British Association Table at the Naples Zoological Station during April, 1907; additional specimens were subsequently sent to me from Naples and the remainder I obtained from the Plymouth Marine Biological Station. As regards methods of preparation, I may remark, first of all, that it is important to fix the lining-epithelium of the bladder and its special development, the gas gland, in a distended condition, and this is best effected by puncturing the bladder (*in situ*) posteriorly and immediately filling it with the fixative used, also pouring fixative on the outside of the bladder. By this means all shrinkage of the bladder wall is avoided on removal from the body. Another advisable precaution is to separate the lining-epithelium of the bladder, after it has been well fixed, from the outer layers of the bladder wall, since I found that in many cases the tough muscle and connective tissue composing these latter cause difficulty in obtaining thin sections across the gas gland. The fixatives which I employed chiefly were Zenker's Fluid, Corrosive Acetic, and Mann's Fluid (Distilled Water 100 c.c., Corros. Sub. 2.5 gm., Picric Acid 1 gm., 40% Formol 10–25 c.c.—a fixative which, in conjunction with Borax Carmine and Picro-indigo-carmine, gave me most beautiful results). Some of my specimens were simply fixed in 10% Formol—a fixative which did not yield such good results as the others, though good enough for most purposes. I left objects in Zenker and Mann overnight, but in Corrosive Acetic only for an hour or so. In many cases I fixed duplicate specimens in different fixatives and was thus able to compare results. Objects fixed with Zenker were well washed for several hours with Distilled Water and then, like the remaining objects fixed with other fixatives, graded slowly up to 70% Alcohol (the percentages being in all cases made up with Absolute Alcohol and Distilled Water). Objects fixed with fluids containing Corrosive Sublimate were treated with Iodine at this stage. In most cases I subsequently stained in bulk with Grenacher's Borax Carmine, leaving the objects in for at least twelve hours, and *without differentiation with Acid Alcohol*, dehydrated, cleared, and embedded in Paraffin. The sections (both longitudinal and transverse in many cases), well stained with Borax Carmine, were then stained on the slide with Picro-indigo-carmine*. This stain is made up by adding one part of a saturated solution of Picric Acid in 90% Alcohol (sat. sol. = circa 4.5%) to two parts of a saturated solution of Grubler's Indig-carmin in 70% Alcohol (sat. sol. = circa 1%), and it is well to dilute this stain so obtained with twice its bulk of 70% Alcohol. The sections are placed in this stain for a short time, varying according to the thickness of the sections and depth of staining with Borax Carmine, from a few minutes to over half an hour.

* I am indebted to Mr. A. D. Darbishire for recommending me this stain.

The Picric Acid, of course, differentiates the Borax Carmine, leaving scarlet nuclei, and the Picro-indigo-carmin stains the cytoplasm of the gas gland a dull green, the cytoplasm of red blood corpuscles and secretion products like zymogen granules a brilliant emerald-green, and connective tissue blue. Curiously enough, I did not always obtain these brilliant colour-contrasts with Zenker, especially if the material had been preserved in Alcohol and Glycerine for some time after fixation, but fixation with Mann's Fluid always yielded the best results. Objects which did not stain well with the Borax Carmine I stained with Ehrlich's Hæmatoxylin and Picro-indigo-carmin, and obtained sufficiently good contrasts. The principal object to be attained by using Picro-indigo-carmin is to show up the blood corpuscles and granules. In exceptional cases I employed the Iron-hæmatoxylin method for nuclear details (in *Perca*, e. g.), also Kernschwarz for rendering visible cytoplasmic edges and hence the limits of intercellular and intracellular ducts (in *Gadus*, e. g.). As above mentioned, most of my gas glands were cut both transversely and longitudinally.

APPENDIX B.

On the Artificial Production of Gas Bubbles in Cells of the Gas Gland.

Of the various methods available for compelling fish to produce gas in their bladder I have employed several, but only with one have I succeeded in detecting the gas bubbles in the act of being formed by the cells. For the guidance of others I will first mention my unsuccessful experiments. I first experimented with *Gobius paganellus* at Plymouth, subjecting this fish to increased pressure due to increased depth—one of the easiest methods of inducing gas-production. I took tank specimens from the Biological Laboratory on board the steam launch, and when anchored well out at sea I enclosed three or four specimens in each of five cages. One cage I let down to a depth of 30 feet and kept it there for one hour and a half; a second cage I let down 60 feet for one hour, a third 90 feet for one hour, a fourth 180 feet for half an hour and a fifth 180 feet for two and a half hours. On examining sections of the gas glands of these fish I could detect no decisive differences in the gland cells. I am unable to explain why this experiment was a failure. Possibly even the maximum time allowed ($2\frac{1}{2}$ hours) was too short in which to allow these cells to become active; possibly also the fact that *Gobius paganellus* is a bottom form may have contributed to this negative result. Another experiment which I may mention was to stimulate the two vagus nerves of an Eel (*Anguilla*) with a battery for three hours, the two sympathetics having been cut and the bladder previously emptied and ligatured. At the end of the three hours the bladder certainly contained about one-sixth of its usual volume of gas, but I was unable to detect bubbles in the cytoplasm. I did not try the experiment of injecting fish with Pilocarpine nitrate or any similar drug.

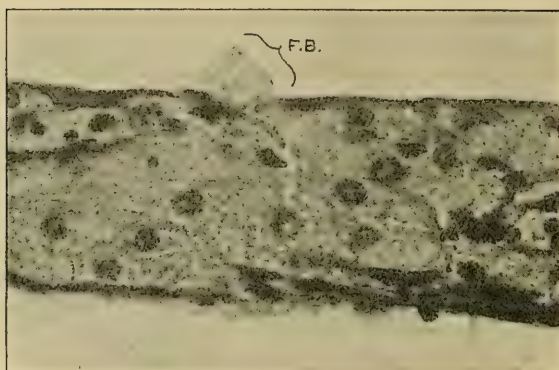
The method by which I achieved success was that of attaching weights to some Perch in a tank in the manner described by Moreau*. The fish, if appropriately weighted, increase the volume of gas in their bladders in order to counteract the sinking action of the weights, but, according to my experience, it is all-important that the weights should not be too heavy, since if the fish are permanently attached to the bottom—if there is no hope of being able to rise—they apparently make no attempt at gas-production. The form of weight I employed was a half-hoop of lead weighing about 5 gm. (approximately one-tenth the weight of the fish, and this was probably too heavy); this I suspended round the lower half of the fish (by thin wires tied dorsally) in the manner of a belt passing dorso-ventrally between the pectoral and pelvic fins, so leaving these perfectly free. After some twelve hours or more the fish can swim about more easily and with a lighter weight it would regain all its usual mobility. If now the weight be removed the fish will rise quite helplessly to the surface of the water, owing to the increased quantity of gas in the bladder. Unless the fish so rises after the experiment it is of little use to examine the gas gland. It is also, of course, necessary to compare the gas gland sections of the fish experimented on with similar sections of a control fish in the same tank. I weighted some six or seven Perch for 17 hours and at the end of that period the bladder of each was appreciably swollen, the fish having to swim vigorously in order to keep below the surface after removal of the weight. I emptied the bladder in the usual manner by a small puncture posteriorly and in several cases refilled it with Zenker's Fluid; in others I used a mixture of one volume of Glacial Acetic with two volumes of Absolute Alcohol, and in others 1% Osmic Acid. Bladders fixed with Zenker I stained with Ehrlich and Picro-indigo-carmin; bladders fixed with the Glacial-Absolute mixture I stained with Iron-haematoxylin in order to study the details of nuclear structure; bladders fixed with Osmic I stained with Ranvier's Picro-carmin. In all cases I made surface-view preparations, laying the bladder with its gas gland inside uppermost on the slide, in addition to cutting numerous sections of various thicknesses of the Zenker and Glacial-Absolute material. The Zenker material gave the best results from the gas bubble standpoint, probably owing to the absence of strong diffusion-currents during the process of fixation; the Glacial-Absolute mixture, on the other hand, though perfect in its fixation of most parts of the cell, was doubtless somewhat drastic in its action on delicate structures like extruded gas bubbles.

The sections of the Zenker material showed up the production of the gas bubbles in a very effective manner, the bubbles being clearly seen to arise in the cell-substance (not shown in text-fig. 61, p. 240) and to be extruded as foam-like masses all over the surface of the gas gland lining the bladder (Pl. IX. fig. 70 and text-fig. 61, the latter being a microphotograph). It must be remarked that only occasional cells were thus active, the majority not exhibiting

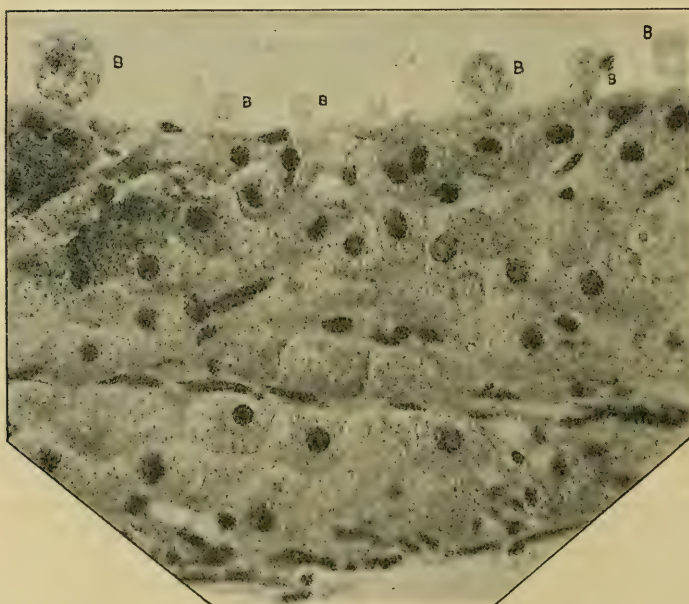
* A more simple method, of course, is to empty the bladder with a trocar.

bubbles. Gas glands must be in a very active condition for the majority of cells to exhibit bubble-structures (see Pl. V. fig. 35 of *Gobius minutus*). These bubbles were quite absent in the sections of non-weighted Perch used for the purpose of controlling the experiment. In my Glacial-Absolute material, structures which are presumably bubbles (very unlike the bubbles seen in most preparations, however) are also to be found in the act of extrusion, but these instead of being unmistakable foam-like masses are bladder-like structures projecting from the cell-periphery (Pl. IX. fig. 71 and text-fig. 62, the latter being a microphotograph) and some are to be found lying free in the bladder-cavity. Possibly the action of the fixative is to cause all the small bubbles of the foam-like mass to run together to form one big bubble. In the surface-view preparations fixed by this method, large gas bubbles are occasionally to be found in the cytoplasm. All these bubble-structures are quite absent in the control material fixed with Glacial-Absolute.

Apart from the existence of gas bubbles in preparations of the activated gland, another distinction from the non-active or dormant gland is the "worked" or "spent" appearance of many of the cells, a distinction which I have tried to indicate in figures 71 and 72 (71 represents cells of the active gland—*cf.* text-fig. 62; 72 represents dormant cells). It was this "spent" appearance, this attenuated and ragged condition of the cytoplasm, which suggested to Nusbaum & Reis that the cell substance actually decomposed into the bladder gases and granular masses, just as the cells of the sebaceous gland disintegrate to produce the secretion of that gland, and, indeed, at first sight of these exhausted cells of the gas gland the suggestion does not seem unreasonable. However, the fact that a cell which possesses but a small amount of protoplasm in the space bounded by its walls is not necessarily in a state of decomposition is shown by the majority of plant-cells, the cytoplasm of which is reduced to a "primordial utricle," by swollen adipose cells, by spicule-cells and by yolk-laden meroblastic eggs, to mention a few out of many possible examples, and since no amount of cytological technique can demonstrate the actual chemical decomposition Nusbaum & Reis assume, this attenuation of the substance of the cells of the gas gland is not of very great significance, especially in view of the reasons for rejecting this suggestion of Nusbaum & Reis already advanced in Part II. It must not be supposed that the cells of my activated glands alone wear this "spent" aspect, all the cells of the dormant gland resembling figure 72; on the contrary, the only difference between the cells of the two glands is one of degree, cells of the dormant gland being, on the whole, less ragged than those of the active. Only a gas gland completely at rest (a condition probably rarely attained in a voracious fish like the Perch) would have all its cells in a resting condition. In most marine fish, however, which I have studied, nearly all the cells of the resting gland have been quite solid in appearance, only the cells of the active gland being attenuated.

Text-fig. 61 (\times circ. 1000).

Microphotograph of transverse section across thin region of gas gland of *Perca* (fixed with Zenker's Fluid), showing foam-like mass of bubbles (F.B.) on surface (cf. Pl. IX. fig. 70).

Text-fig. 62 (\times circ. 1000).

Microphotograph of transverse section across thick region of gas gland of *Perca* (fixed with Absolute and Glacial Acetic), showing extruded gas bubbles (B) on surface (cf. Pl. IX. fig. 71). The "spent" condition of the cells is also shown.

In connection with the two microphotographs of gas bubbles here reproduced as text-figures 61 and 62, I may say that these structures were in my preparations very difficult subjects for photography, partly because of the inappropriate staining employed and partly because bubbles shown in optical section of necessity bear but little resemblance to the real thing (this was especially the case with the foam-like mass indicated in text-fig. 61; *cf.* fig. 70). Nevertheless, these microphotographs, taken for me by Mr. F. J. Pittock, of the Zoological Department, University College, are perhaps of value as affording impartial evidence of the appearance of an active gas gland epithelium, also of the "spent" condition of the cytoplasm. Microphotographs were also taken of intracellular bubbles, but, owing to the thickness and staining of the sections, were not suitable for reproduction.

ADDENDA.

(1) The statement that gas glands are normally quiescent may not be strictly accurate; it would perhaps be more correct to say that only on occasion do gas glands assume *great* activity. I make this remark in consequence of a communication from Lieutenant G. C. C. Damant, R.N., who kindly permits me to repeat it. From observations made under water during diving operations and from the results obtained in catching fish on the hook at different states of the tide, Lieut. Damant concludes that Pout, *e. g.*, remain fairly constantly at one level, *viz.*, just off the bottom, whatever the state of the tide may be. If this be the case, it follows, as Lieut. Damant suggests, that the gas gland must become functional during each rise of the tide in order that a periodic increase of gas in the bladder may counteract the periodic increase of external pressure.

(2) It seems probable, from suggestions kindly made to me by Dr. G. A. Buckmaster and Dr. G. C. Mathison, that the principal factor in the evolution of erythrocytes in Vertebrates has been the necessity for a greatly increased quantity of hæmoglobin in Vertebrate blood as compared with Invertebrate—a necessity corresponding to greater functional activity. It is suggested that the amount of hæmoglobin required to be present in Vertebrate blood would be more than the plasma could possibly hold in solution, and that even if this were possible the viscosity of the plasma produced would seriously interfere with the other functions of the plasma, which, like the respiratory, have, in Vertebrates, increased in intensity. This large quantity of hæmoglobin in Vertebrate blood being requisite and its presence in the plasma prohibited, the evolution of erythrocytes in which the hæmoglobin is imprisoned and combined with a proteid has apparently been the only alternative. As I have before remarked, the lack of direct contact between the tissues and the respiratory pigment in Vertebrates is compensated for both by the rapidity of the circulation and by the amount of the respiratory pigment present, and doubtless also by the increase in amount of the waste

products of active tissues which act as reducing agents and so facilitate the abstraction of the oxygen dissolved in the plasma.

(3) I have adduced the striped darkening of the cytoplasm of the gas gland cells bordering the capillaries as evidence of the absorption of dissolved oxyhæmoglobin from the blood and that this is evidence of absorption is undoubted, but that it is absorption of oxyhæmoglobin is of course only an inference from the hæmolysis of the blood corpuscles, the production of oxygen gas by the gland cells and other considerations. I wish to state here, previous to sending away the final proofs of this paper, that, judging from preliminary experiments with the Israel-Pappenheim stain for hæmoglobin, kindly recommended to me by Dr. G. A. Buckmaster, I have been able to detect the actual presence of hæmoglobin in the cells of the active gas gland and its passage thereto from the blood stream, and Dr. Buckmaster has confirmed these preliminary observations of mine. I intend to repeat these observations on an extended scale on fresh material shortly, and until I have done so I do not wish the above statement to be considered as final.

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EXPLANATION OF PLATES II.-IX.

[All figures of sections drawn with the aid of the camera lucida. In figures 4, 9, 13, 14, 15, 26, 38, 46, 49, 52 and 57, which, like most of the others, have been greatly reduced in size during the process of reproduction, the capillaries of the rete mirabile have not been reduced to nearly the same extent as the other parts of the figures, since, had this been done, they would have been invisible.]

Anguilla vulgaris (Pl. II. figs. 1-8).

- Fig. 1 ($\times 18$). Semi-diagrammatic transverse section through the anterior end of gas bladder (A.B.) and pneumatic duct (P.D.). G.E., glandular epithelium of bladder; D.E., epithelium of duct; A., artery, and V., vein supplying bladder.
- 2 ($\times 18$). Similar section, more posterior. The artery and vein have each divided, each pair of vessels consisting of an artery and a vein.
- 3 ($\times 18$). Still more posteriorly the artery and vein of each pair have subdivided so as to form a mass of intermingled arteries and veins.
- 4 ($\times 18$). Each mass of arteries and veins has, just before the pneumatic duct joins the bladder, subdivided to form a bunch of minute parallel arterial and venous capillaries—the rete mirabile bipolare geminum (Müller) here seen in transverse section.
- 5 ($\times 18$). Where the duct joins the bladder, the minute capillaries of the rete mirabile have reunited to a considerable extent, arteries with arteries and veins with veins, to form large vessels, which then recapillarize in order to supply the gas gland. P.D., pneumatic duct which has now altered the character of its epithelium and become part of the bladder, P.B.
- 6 ($\times 18$). Semi-diagrammatic transverse section through the posterior region of the bladder, P.B.
- 7 ($\times 500$). Transverse section through the lining epithelium of the pneumatic duct. Note the large capillaries and squamous epithelium covering them.
- 8 ($\times 500$). Transverse section through the glandular epithelium of the bladder (gas gland). G.D., one of the gland ducts formed by the folding of the epithelium.

Ophichthys (Sphagebranchus) imberbis (Pl. II. fig. 9).

- Fig. 9 (\times cir. 10). Semi-diagrammatic transverse section through "red body," where the duct (P.D.) joins the bladder (B.). R.M., the single rete mirabile, the long axis of which is situated transversely in the ventral bladder wall. The capillaries of the rete are here seen in longitudinal section.

Syngnathus acus (Pl. II. figs. 10-13; Pl. III. figs. 14-21).

- Fig. 10 ($\times 27$). Semi-diagrammatic transverse section through the anterior attachment of the bladder. A. and V., arteries and veins which subdivide to form the rete mirabile; Ves., vessels not taking part in the formation of the rete; B.G., masses of the diffuse pancreas.
- 11 ($\times 27$). The arteries and veins are here subdividing to form the rete mirabile.
- Figs. 12, 13 ($\times 27$). The formation of the rete mirabile (R.M.).
- Fig. 14 ($\times 27$). The anterior end of the bladder (A.B.) has just appeared. The rete mirabile (R.M.) is fully formed.
- 15 ($\times 27$). The arterial and venous capillaries of the rete mirabile have reunited to form larger vessels which then recapillarize to supply the bladder epithelium (G.E.). B., bladder cavity.
- Figs. 16-18 ($\times 27$). The vessels of the rete mirabile gradually disappear in supplying the bladder epithelium.
- Fig. 19 ($\times 500$). A fold of the "unthickened" bladder epithelium. B.L., gland duct between folds of epithelium; G.S., granular matter present in only very minute quantity; V.D., darkened zone of cytoplasm round capillary wall.
- 20 (\times cir. 1000). Transverse section through rete mirabile. Venous capillaries indistinguishable from arterial. S.G., disintegration-products of the erythrocytes.
- 21 ($\times 1600$). Stages in disintegration of the red blood corpuscles situated in the capillaries of the gas gland. S.G. as in fig. 20.

Gobius niger (Pl. III. fig. 22; Pl. IV. figs. 23-32, 34; Pl. V. fig. 33).

Fig. 22 ($\times 1$). Appearance of the "red body" in the ventral bladder wall.

- 23 ($\times 16$). Semi-diagrammatic transverse section anterior to the "red body."
A. and V., the initial artery and vein which form the rete mirabile;
B.G., pancreas masses; O.L., outermost layer of the bladder wall;
G.E., glandular epithelium lining bladder cavity. It will be
noticed that the vessels and pancreas lie outside the bladder wall.
- 24 ($\times 16$). More posterior section. The initial artery and vein have subdivided
to a small extent. The outermost layer of the bladder wall has
become broken through by the arteries, veins and masses of
pancreas.
- 25 ($\times 16$). The arteries and veins, intermingled with masses of the pancreas,
are rapidly subdividing to form the rete mirabile and the whole
mass is now practically situated inside the bladder wall.
- 26 ($\times 16$). The rete mirabile (R.M.) has now commenced to supply the
glandular epithelium (G.E.) and is situated wholly inside the
bladder wall, *i. e.* internal to the outermost layer (O.L.). B.G.,
portion of the pancreas remaining external to the bladder.
- 27 ($\times 330$). Three folds of the bladder glandular epithelium in transverse
section. C.R.M., minute capillaries of the rete mirabile; BU.,
gas-bubble; IC.C., intracellular capillary.
- 28 ($\times 800$). Gas gland cell with intracellular capillary (IC.C.). Note the
striped darkened zone of cytoplasm next the capillary.
- 29 ($\times 800$). Gas gland cells with inter- and intracellular capillaries (IC.C.).
- 30 ($\times 800$). Gas gland cell with intracellular lumen in transverse section.
Intracellular ducts, when thus seen, are not always easy to
distinguish from bubbles.
- 31 ($\times 800$). Gas gland cell with intercellular lumen (INT.C.L.) in transverse
section.
- 32 ($\times 1000$). Transverse section through anterior end of rete mirabile, showing
the curious endothelium (END.) of the arteries in this region and
the large amount of erythrocyte-disintegration granular matter
contained in the veins. The arteries (A.) are here distinguishable
from the veins (V.) by their smaller size, by their thicker walls, by
possessing the curious endothelium and by being practically free
from granular matter (S.G.).
- 33 ($\times 800$). A duct of the pancreas in longitudinal section. The numerous
nuclei and the syncytial character of the wall are noticeable. A
large amount of granular secretion-matter is present in the duct.
- 34 ($\times 800$). A duct of the pancreas in transverse section.

Gobius minutus (Pl. V. fig. 35).

Fig. 35 ($\times 1000$). Portion of the folded epithelium of the gas gland in a very active
condition. Bubbles are seen being produced (usually near the
nuclei) in the interiors of most of the cells, others are being
extruded from the cells and one is shown lying freely in the
bladder cavity. The large amount of granular matter lying in the
bladder lumen external to the gas gland cells which has resulted
from the bursting of extruded bubbles is noticeable.

Siphonostoma typhle (*rondeletii*) (Pl. V. fig. 36).

Fig. 36 ($\times 1000$). In addition to the erythrocytes there are shown three of the
curious "white" corpuscles which are so striking in appearance in
this fish, the cytoplasm being very dense. These corpuscles are
numerous.

Peristethus cataphractus (*Peristedion cataphractum*) (Pl. V. figs. 37-41).

Fig. 37 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

38 ($\times 16$). Semi-diagrammatic transverse section across the anterior end of the
"red body" (see A-B, text-fig. 57, p. 202). S.E., squamous
epithelium lining the greater part of the bladder; G.E., glandular
epithelium; R.M., rete mirabile.

Figs. 39-41 ($\times 1600$). Cells of the gas gland showing formation of bubbles in
cytoplasm.

Trigla hirundo (Pl. V. fig. 43; Pl. VI. figs. 42, 44).

Fig. 42 ($\times 1$). Lateral "red bodies" (L.R.M.) as seen in ventral wall of bladder (=lateral divisions of the elongated "red body," the median divisions being hidden by the muscle-bands, M.B., in the middle). G.E., the glandular epithelium (too broad in figure).

43 ($\times 16$). Semi-diagrammatic transverse section through the middle of the "red body" represented in fig. 42. M.B., two strong muscle-bands on each side of the middle line; R.M., rete mirabile; L.R.M., lateral rete mirabile; G.E., glandular epithelium; S., strand of nerve-fibres supplying muscles.

44 ($\times 250$). Glandular epithelium of bladder in transverse section. B.L., gland duct.

Smaris vulgaris (Pl. V. fig. 46; Pl. VI. fig. 45).

Fig. 45 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

46 ($\times 16$). Semi-diagrammatic transverse section across anterior end of "red body." R.M., rete mirabile; G.E., gas gland epithelium; S.E., general squamous epithelium lining bladder; B.L., bladder cavity.

Smaris maurii (Pl. VI. fig. 47).

Fig. 47 ($\times 250$). Pseudo-massive epithelium of gas gland in transverse section. As explained in the text, this type of epithelium is without doubt a derivative from the folded type and so differs from truly massive types of gas gland epithelia which are not secondarily derived from a folded condition. The perivascular spaces seen in the figure are, in most cases at least, due to contraction.

Ophidium barbatum L. (Pl. VI. figs. 48-50).

Fig. 48 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

49 ($\times 16$). Semi-diagrammatic transverse section across "red body." S.E., squamous epithelium; G.E., gas gland epithelium; R.M., rete mirabile. Outer layers of the bladder wall stripped off.

50 ($\times 800$). Large gas gland cells with intracellular ducts (I.C.D.), which possibly represent the passages of bubbles to the exterior. B.L., bladder cavity; INT.C.D., intercellular duct.

Box boops (Pl. VI. fig. 51; Pl. VII. fig. 52).

Fig. 51 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

52 (\times cir. 27). Semi-diagrammatic transverse section through the middle of the "red body" shown in preceding figure. R.M., rete mirabile; S.E., squamous epithelium; G.E., gas gland epithelium; B.L., bladder cavity.

Atherina hepsetus (Pl. VI. fig. 53; Pl. VII. figs. 54, 55).

Fig. 53 ($\times 1$). Appearance of "red body" in ventral wall of bladder (only the vessels and retia mirabilia are seen).

54 ($\times 1000$). The glandular epithelium in transverse section.

55 ($\times 1000$). The glandular epithelium of a young *Atherina* (15 mm. long) showing incipient division of the cells in a plane at right angles to the bladder wall. C.T.C., connective tissue cells. Notice the large size of the nuclei as compared with those in the adult gland of another specimen. Though no capillaries are shown in the figure, yet they are plentiful in most parts of the gland.

Coris julis (Pl. VI. fig. 56; Pl. VII. figs. 57, 58).

Fig. 56 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

57 ($\times 16$). Semi-diagrammatic transverse section of "red body." Lettering as before.

58 ($\times 500$). The glandular epithelium in transverse section. B.L., bladder cavity; S.E., superficial squamous layer of the glandular mass; BU., gas bubble; INT.C.D., narrow intercellular lumen.

Corvina nigra (Pl. VII. fig. 59).

Fig. 59 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

Sargus rondeletii (Pl. VIII. fig. 60).

Fig. 60 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

Balistes capriscus (Pl. VIII. fig. 61).

Fig. 61 ($\times 1$). Appearance of "red body" in ventral wall of bladder. The "red body" is, in this case, situated posteriorly in the bladder, not anteriorly.

Zeus faber (Pl. VIII. figs. 62-64; Pl. IX. fig. 65).

Fig. 62 ($\times 1$). Appearance of "red bodies" in ventral wall of bladder. R.M., rete mirabile; G.E., gas gland; M., anterior muscular band.

63 ($\times 375$). Transverse section across base of massive gas gland showing syncytial masses which probably represent the regenerating portion of the gland. Cell-outlines only become visible in the more peripheral regions. The syncytial nuclei divide by ordinary mitosis and are of several sizes, giant nuclei being among them.

64 ($\times 666$). Amitotic division of nuclei in some small giant cells, intermediate-sized cells and small cells of the gas gland. The nucleolus seems to be the first part of the nucleus to divide.

65 ($\times 375$). A binucleated giant cell surrounded by the ordinary small cells. Compare the magnification of this with the last figure.

Gadus morrhua (Pl. VIII. fig. 66).

Fig. 66 ($\times 27$). Semi-diagrammatic transverse section across "red body." R.M., tufts of rete mirabile; G.E., gas gland epithelium; M.C., cap of connective tissue; B.L., bladder cavity.

Cepola rubescens (Pl. VIII. fig. 67; Pl. IX. fig. 68).

Fig. 67 ($\times 1$). Appearance of "red body" in ventral wall of bladder.

68 ($\times 333$). Glandular epithelium in transverse section. The perivascular darkening of the cytoplasm is here very marked. The ducts of the gland are very thin and inconspicuous.

Perca fluviatilis (Pl. IX. figs. 69-72).

Fig. 69 ($\times 1$). Appearance of branched "red body" in ventral wall of bladder, the portions of gas gland forming margins to the small fan-shaped retia mirabilia.

70 ($\times 1000$). A small portion of the gas gland of *Perca* (fixed with Zenker) showing the evolution of bubble-masses from the cytoplasm in certain cells of the epithelium, consequent upon the experiment of weighting the fish (Appendix B, cf. text-fig. 61, p. 240).

71 ($\times 1000$). Cells of the gas gland of *Perca* (fixed with the Glacial-Absolute-mixture) exhausted by the activity of the gland (cf. text-fig. 62). One of the bladder-like structures is shown in connection with one of the cells.

72 ($\times 1000$). Unexhausted, i. e. inactive cells of the gas gland of *Perca* (fixed by the same method) for comparison with those of fig. 71.

Nerophis æquorius (Pl. IX. fig. 73).

Fig. 73 ($\times 666$). Five gas gland cells of *Nerophis* in contact with a capillary. This figure, coloured to resemble my preparations as far as possible, shows in the gas gland cell the striped zone of cytoplasm next the capillary wall (indicative of absorption) and the erythrocyte-disintegration granular material present in the blood.

12. On Skulls of Oxen from the Roman Military Station at Newstead, Melrose. By J. C. EWART, M.D., F.R.S., F.Z.S.*

[Received and Read February 7, 1911.]

(Text-figures 63-91.)

Professor Marcellin Boule, in his recent work on the Grotto of Grimaldi †, states that Cuvier, Rüttimeyer, Nehring, Gaudry, Boyd Dawkins, Duerst, and other naturalists who have studied the Quaternary Bovidae have regarded the Urus (*Bos taurus primigenius*) as identical with our modern *Bos taurus*, of which it was probably the ancestor, and from which it differed only by its greater size.

Though many naturalists since the days of Cuvier have directed their attention to the history of Domestic Cattle, the last word has not yet been said about their origin, hence in dealing with the remains of cattle from the Roman Military Station at Newstead, Melrose, the investigator must still bear in mind that a final answer has not yet been given to the question—Are modern European cattle descended from the Urus, *Bos taurus primigenius*? When discussing the origin of British cattle Prof. Hughes remarks: "Cæsar mentions that there were large herds of domesticated cattle in Britain, and we know from numerous excavations into Roman and Roman-British rubbish-pits that these belonged not to the Urus but to *Bos longifrons*. This, then, is the native breed with which we must start in all our speculations as to the origin and development of British oxen. The Romans found that breed here and no other."

Writing about the Celtic Shorthorn (*Bos longifrons* Owen, *Bos brachyceros* Rüttimeyer) Mr. Lydekker says, "It is, and can be, nothing but a variety of *Bos taurus*" derived from the wild Urus at a very remote epoch—"the occurrence of remains of an apparently similar breed in the prehistoric lake-dwellings of Switzerland suggests that the breed may have been established prior to the separation of Britain from the Continent" ‡.

Bos frontosus Nilsson, Lydekker also regards as a variety of the Urus, and as there was no other primitive Wild Ox in Europe, and an Eastern derivation being in the highest degree improbable, Lydekker says that all the domesticated breeds of European cattle must trace their ultimate ancestry to *Bos primigenius*. While satisfied that the Domestic Cattle of Europe are descended from *Bos primigenius*, Lydekker thinks it is quite probable that the origin of the humped cattle of India (*Bos indicus*) may be, at least in part, different.

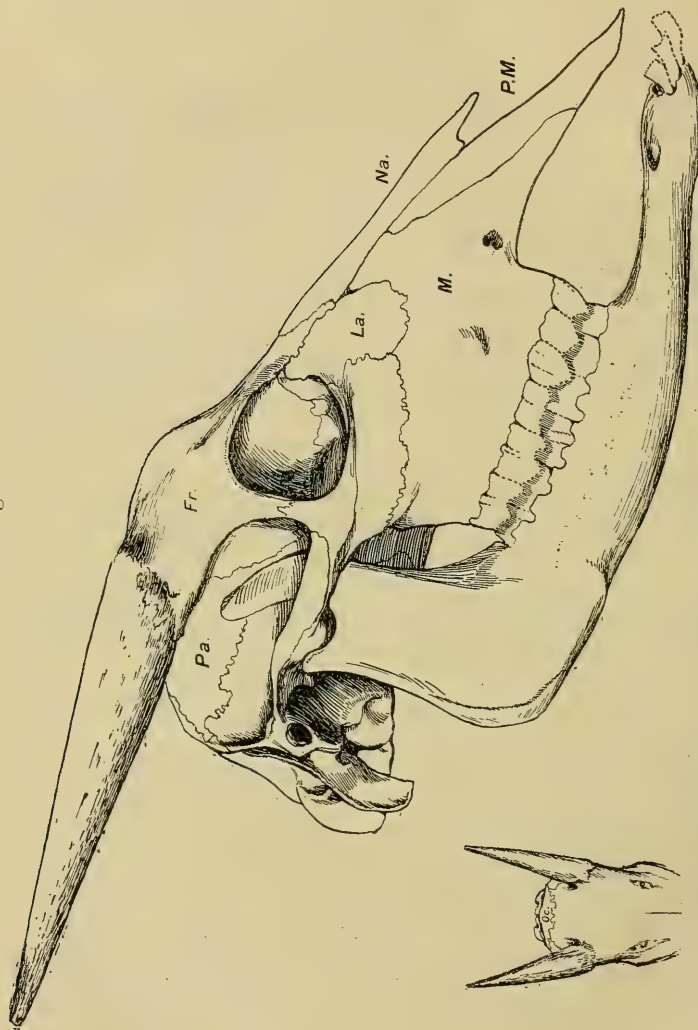
* The author is indebted to Mr. James Curle, Priorwood, Melrose, for the use of the Oxen skulls found at Newstead.

† 'Les Grottes de Grimaldi,' tome i. fascicule iii., 1910.

‡ 'Wild Oxen, Sheep, and Goats,' p. 18, 1898.

Though Professor Fairfield Osborn thinks that the Domestic Ox, instead of being a direct descendant of *Bos primigenius*, is a descendant of *Bos trochoceros* of the Italian Pleistocene, he differs

Text-fig. 63.

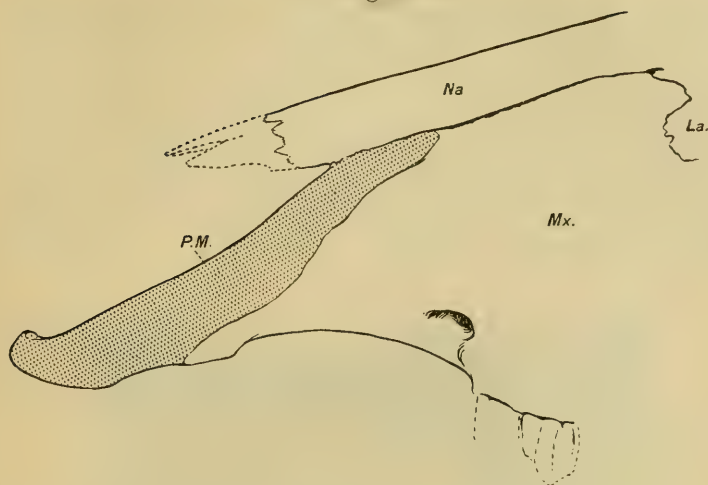


Skull of the Anoa (*Bos depressicornis*), in which the premaxillæ (*P.M.*) extend well upwards between the maxillæ (*M.*) and nasals (*Na.*). The horns occupy nearly the same position as in Antelopes. From a skull in the Royal Scottish Museum.

in no essential point from Lydekker, and, like Lydekker, believes British Shorthorn Cattle are descended from an indigenous Occidental race domesticated in Europe by the Neoliths*. A somewhat different view is taken by Prof. Boyd Dawkins, who

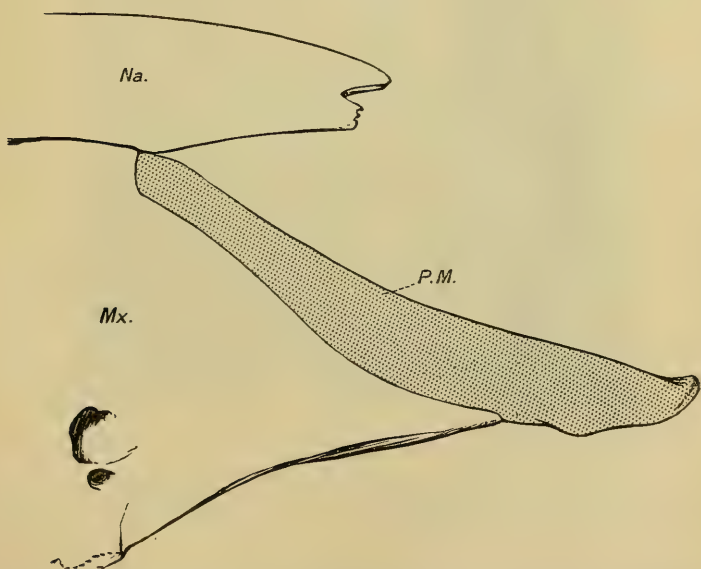
* Osborn, 'The Age of Mammals,' 1910.

Text-fig. 64.



Front part of the skull of a Buffalo (*Bos bubalus*).
The premaxillæ (*P.M.*), as in the Anoa, extend upwards between the maxillæ and nasals.

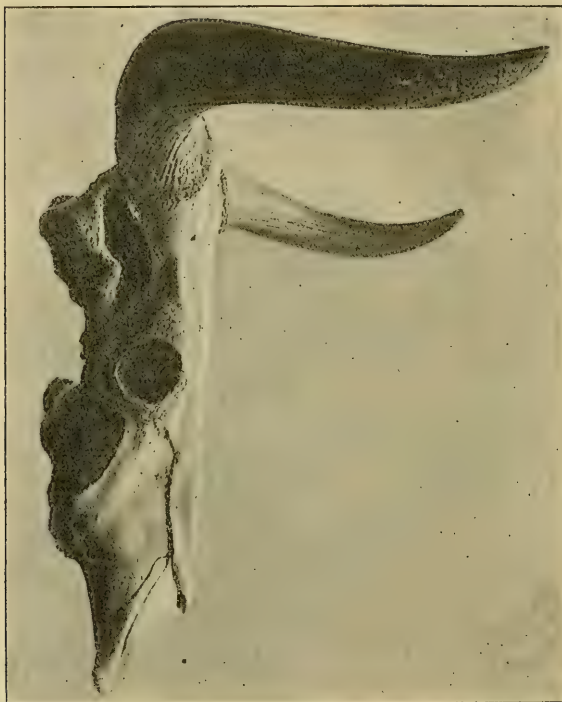
Text-fig. 65.



Front part of skull of the Urus (*Bos primigenius*).
In this skull the premaxillæ are only slightly connected with the nasals, but in a skull in the British Museum the premaxillæ extend nearly as far upwards between the maxillæ and nasals as in the Buffalo (text-fig. 64).

says: "It is clear the domestic animals were not domesticated in Europe, but that they had already been under the care of Man probably for long ages in some other region. The Turf-Hog, the Celtic Shorthorn, the Sheep, and the Goat have been domesticated in the countries in which their wild ancestors were captured by the hunter in Central Asia. To this region also belong the Jackal, the Wild Boar, and the Wild Horse, and in ancient times the Urus. It is therefore probable that all these domestic animals came into Europe with their masters from the south-east—from the Central plateau of Asia—the ancient home of all the present European peoples."

Text-fig. 66.



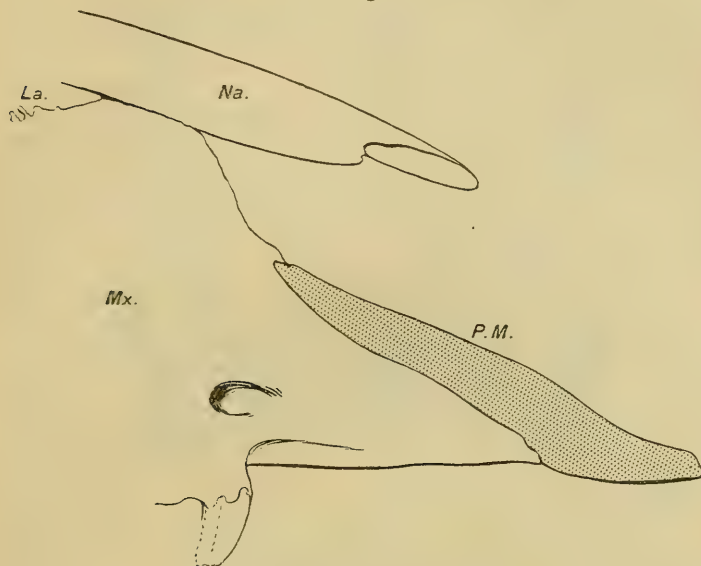
Skull of a Urus in the Anatomical Museum, University of Edinburgh.

The premaxilla has only a slight connection with the nasal, the forehead is flat, the temporal fossa is closed behind, and the horn-cores curve forwards at nearly a right angle to the forehead.

Of Continental zoologists, Prof. Duerst has for some years been directing most attention to the origin of domestic animals. In his report on the Animal Remains found in Turkestan by the

Pumpelly Expedition, Duerst says: "My recent studies on fossil remains of the bovines of the Indian Pleistocene have shown

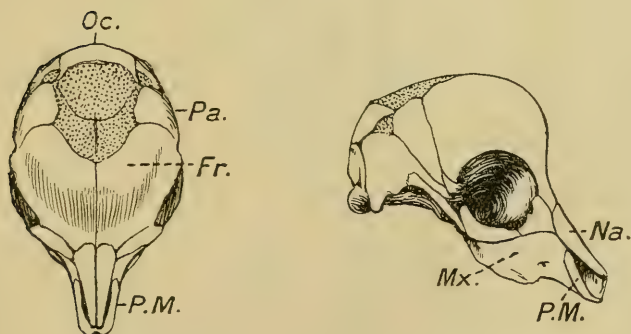
Text-fig. 67.



Front part of skull of American Bison.

The premaxillæ are short and far removed from the nasals.
From a skull in the Anatomical Museum, University of Edinburgh.

Text-fig. 68.



Front and side views of the skull of a young fetal Ox. Nat. size.

The premaxillæ (*P.M.*) reach the nasals (*Na.*), the frontals (*Fr.*) extend nearly as far backwards as in the adult Anoa, and there is a large gap between the frontals (*Fr.*), parietals (*Pa.*), and supra-occipital (*Oc.*).

me that the Indian (Narbada and Siwaliks) and China *Taurina* are the exact equivalents of the European *Urus* (*Bos primigenius* Bojanus), excepting some very slight variations produced by different geographical and local influences, so that the *Bos namadicus* Falconer and Cautley would represent the European *Urus* for the Asiatic Continent, especially the North Indian mountains and their neighbourhood”*.

In recapitulating the results of his studies of the bovids of Anau, Duerst says:—“In the lower layers of period Ia from — 24 feet upwards there occur the remains of a wild *Bos namadicus* Falconer and Cautley. During period Ib there originates from this wild form a domesticated bovid, large and stately, provided with long horns. Judging from the measurements of the preserved bones this is absolutely the same Ox that was possessed by the Ancient Egyptians.

“In the period II the size of the animal seems to have somewhat diminished, unless possibly a smaller bovid reached Anau with the other newly imported domestic animals. It is, however, possible that this form of cattle of the culture II originated in a decline of the cattle-breeding of the later Anau-li; as, indeed, the originally large long-horned Ox of the early Babylonians had already become small and short-horned in Assyrian times, and to-day, after a relatively shorter interval, shows a tendency to become hornless”†.

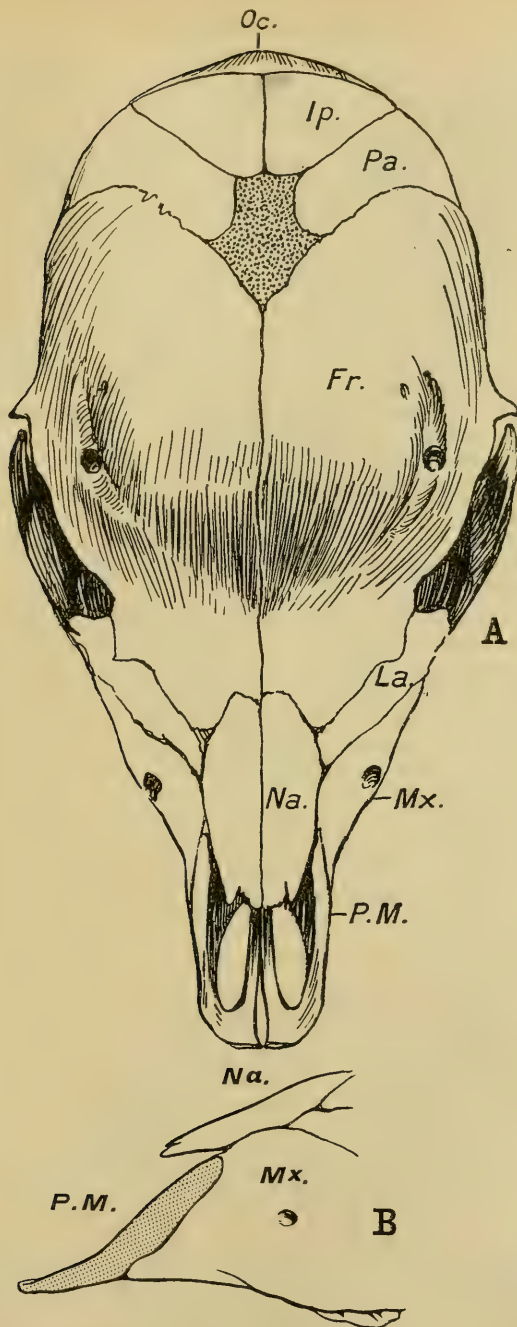
Duerst goes on to say:—“The first remains of the long-horned breed (*Bos taurus macroceros*) belong at Anau about 8000 B.C. We find the same animal again about 3000 to 4000 B.C. in Babylonia and Egypt. At about 6000 B.C., however, we find that the large long-horned animal of Anau has become small and small-boned and has developed into a short-horned breed (*Bos brachyceros*)‡. Therefore all who do not believe in an autochthonous domestication of the animals for each separate culture-sphere must admit that the original large and stately long-horned Ox of Anau was spread by tribal migrations before 6000 B.C. to Persia and Mesopotamia and into Egypt and Central Africa on the one hand and on the other to India and Eastern Asia, where according to Chinese accounts it arrived in 3468 B.C.

“Did the migration of the West occur only after the small breed had become established, *i. e.* about 6000 B.C., or even between 6000 and 7000 B.C. when the turbary sheep had formed? To this question we have as yet no answer. We must, however, add that it was not in Anau alone that through unfavourable conditions of life the originally large and stately Ox was changed into the stunted and short-horned form (*Bos taurus brachyceros*). The same change took place in Mesopotamia, as one may easily perceive in comparing the long-horned cattle of Chaldean or Sumero-Accadian times with the Assyrian small short-horned and the

* ‘Animal Remains from Excavations at Anau,’ Carnegie Institution of Washington, p. 361.

† Duerst, *op. cit.* p. 369.

‡ *Bos brachyceros* is the same as *Bos longifrons*.



A.—Front view of a fetal Ox skull about the fifth month. The premaxillæ (*P.M.*) reach the nasals (*Na.*), the frontals (*Fr.*) are long, the parietals (*Pa.*) narrow, and the interparietals (*Ip.*) lie between the parietals and supra-occipital. Nat. size.

B.—Front part of same skull, to show relation of premaxillæ to nasals. Nat. size.

modern loose and short-horned or hornless cattle. There is, therefore, no reason for rejecting the assumption or hypothesis that the Ox of Anau, which about 7000 B.C. was undergoing this change of form, finally reached Central Europe, after its migration through Southern Russia and Eastern Europe, in the stunted form of *Bos taurus brachyceros*," * *i. e.* in the small Celtic Shorthorn generally known in England as *Bos longifrons*.

If the conclusions arrived at by Duerst and others are justified, it follows (1) that all the modern domestic cattle—the humped breeds of India and Africa as well as the European breeds—are derived either from the Urus of Europe (*Bos taurus primigenius*) or its reputed near relative the Urus of Asia (*Bos namadicus*), or are a blend of varieties or races of these two species; and (2) that modern British breeds have been formed by crossing the Celtic Shorthorn (*Bos longifrons vel brachyceros*)—the small domesticated race widely distributed over Britain in pre-Roman times—with Continental breeds (including short-horned as well as long-horned varieties) introduced since the Roman invasion. Are these conclusions supported by the remains of cattle from the border-forest occupied by Roman auxiliaries during the first and second centuries of the present era?

Prof. Boule, in his recent work on the Grimaldi fossils, says the genus *Bos* (which includes the most specialized members of the Bovid family) seems to have been represented in Pliocene times by *Bos planifrons* and *Bos acutifrons* of the Siwalik deposits of India. Duerst regards *Bos planifrons* † as the ancestor of both *Bos primigenius* and *Bos namadicus*, but Rüttimeyer thinks that though *Bos planifrons* may be ancestral to, it is only a variety of *Bos primigenius*, the European variety of *Bos namadicus*.

Though *Bos primigenius*, like the Bison, only reached Europe in Quaternary times, it was soon widely distributed—its remains occur in English Pleistocene deposits containing *Elephas antiquus* and in deposits of a like age over the greater part of Europe and also in North Africa. While *Bos primigenius* was extending its range over Europe, *Bos namadicus* was spreading over Asia.

It has hitherto been supposed that the Bison was more abundant in Europe during Pleistocene times than the Urus, but Prof. Boule believes that, at least in the vicinity of Grimaldi, the Urus was from the first as common as the Bison.

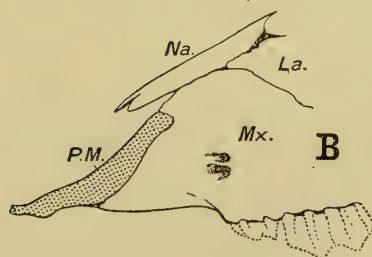
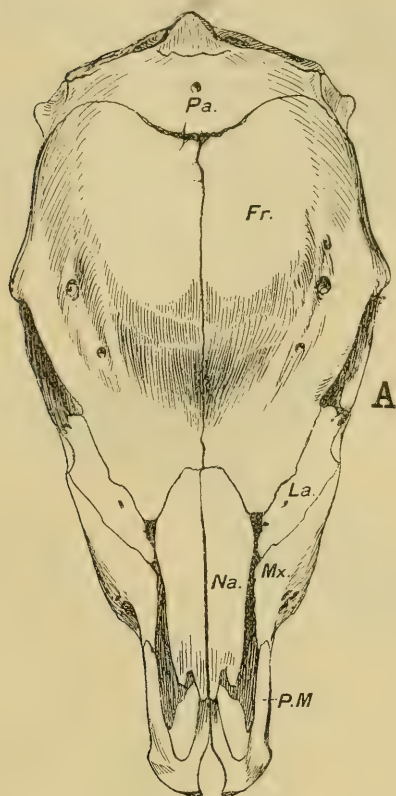
About the colour of the Urus nothing absolutely certain is known, but from drawings of Mediæval, as well as Palæolithic artists we can form a fairly accurate conception of its conformation. A picture, believed to have been made in Bavaria about 1500 A.D., probably brings out the chief points of *Bos primigenius* ‡.

* Duerst, *op. cit.* p. 440.

† According to Duerst's latest view there is no real difference between *Bos planifrons* of Rüttimeyer and *Bos acutifrons* of Lydekker, but at one time he believed *Bos acutifrons* was the predecessor of *Bos namadicus*, to which the Bovine (Gaur and Banting) group and especially the Indian Zebu were related.

‡ This picture is reproduced in the 'Cyclopædia of American Agriculture,' vol. iii. 1900; the Urus apparently survived in Poland up to 1627.

Text-fig. 70.

**A.**—Front view of Calf's skull at birth.

The premaxillæ (*P.M.*) fail to reach the nasals (*Na.*). The parietals and interparietals have coalesced to form a narrow plate (*Pa.*) between the frontals (*Fr.*) and supra-occipital.

B.—Front part of same skull.

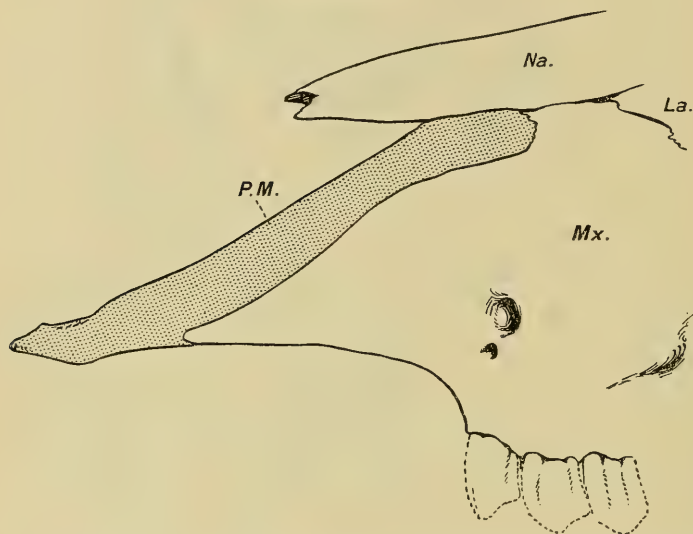
The premaxilla (*P.M.*) is short and some distance from the nasal (*Na.*).

Text-figs. 69 & 70, from specimens belonging to Prof. Charnock Bradley, D.Sc.

The Urus was widely distributed in Britain in Neolithic times, but the examination of Roman and Roman-British stations has hitherto afforded no evidence that *Bos primigenius* still survived in England at the Roman invasion.

A number of more or less complete skulls of the Urus have been found in Scotland, and fragments of skulls, limb-bones, or horn-cores believed to belong to the Urus have been found in almost every county in Scotland between the Solway and the Pentland Firths, and some horn-cores found in Orkney are so large that it is assumed they belong to *Bos primigenius*.

Text-fig. 71.



Front part of skull of a polled Aberdeen-Angus Ox, with premaxillæ (*P.M.*) extending nearly as far up between the maxillæ (*Mx.*) and nasals (*Na.*) as in the Buffalo (text-fig. 64, p. 251). From a specimen in the Royal Scottish Museum.

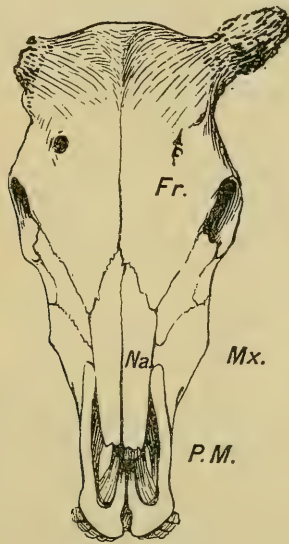
Though there is no evidence that the Urus survived long enough in England to give rise to the Chillingham and other "wild" white park cattle, it has been suggested that a sufficient number survived in the Caledonian forests to found the Cadzow, Atholl, or other Scottish herds of "wild" cattle. The bones from Newstead, however, afford no evidence that the Urus still survived in Scotland when the Romans constructed the border-fort during the later part of the first century A.D.

The skull of *Bos taurus primigenius* is in some respects more highly specialized than that of any other member of the Bovidæ. Hitherto in studying bovine skulls a very considerable amount of attention has usually been directed to the position, size, and

direction of the horns. I shall, however, especially refer to the premaxillæ, occiput, and temporal fossæ.

1. *The Premaxillæ*.—In some Zebras (*e. g.* the true Burchell Zebra) the premaxilla may only be connected with the nasal for a distance of 12 to 15 mm., while in others (*e. g.* a variety which lives near Lake Baringo) the connection between the nasal and the premaxilla may exceed 50 mm. Differences in the food may account for the premaxillæ being long in some cases and short in others. The premaxillæ may require to be firmly wedged in between the maxillæ and nasals in varieties in varieties in the habit of feeding during part of the year on coarse hard food, but only slightly connected with the nasals in varieties which usually consume soft green herbage.

Text-fig. 72.



Skull of a Syrian Ox with vestigial horn-cores and a forehead like that of flat-polled Aberdeen-Angus cattle; the premaxillæ (*P.M.*) as in text-fig. 71 extend far up between the maxillæ (*Mx.*) and nasals (*Na.*). From Wilckens, 'Naturgeschichte der Haustiere.'

In the Anoa (*Bos depressicornis*) of Celebes and in the wild Indian Buffalo (*Bos bubalus*) the premaxillæ are firmly wedged in between the maxillæ and nasals. In the Anoa (text-fig. 63, p. 250) the total length of the premaxilla is 105 mm., and its connection with the nasal is 35 mm.; in the Buffalo (text-fig. 64) the total length of the premaxilla may be 173 mm., and its connection with the nasal 40 mm.

This long intrusion of the premaxilla between the nasal and

maxillary bones doubtless increases the strength of the front part of the jaw which supports the horny pad against which the lower incisors bite. As the Anoa is partial to the neighbourhood of water, it probably feeds on coarse grasses like its ally the Tamarau of the island of Mindoro, which is said to browse on sugar-cane.

The Indian Buffalo lives in the neighbourhood of swamps and jungles, and probably also feeds on reeds and coarse grasses—food which necessitates long, firmly secured premaxillæ.

In the Catalogue of the Ungulata in the British Museum Dr. Gray says that in the true Oxen "the premaxillæ are large and always extend upwards into the triangular space between the maxillæ and the nasals and consequently articulate with both these bones as in *Bubalus* ; in the genus *Bibos*, on the other hand, the premaxillæ are small and are attached only to the distal extremity of the maxilla and are separated by a considerable interval from the nasals." As will appear below, the premaxillæ, instead of being always long enough in true Oxen to extend upwards between the maxillæ and nasals as in the Buffalo, are sometimes so short that they fail to reach the nasals as in the Bison (text-fig. 67, p. 253).

In *Bos primigenius* the premaxillæ, in all the skulls I have examined, reach the nasals. In some cases the connection with the nasals is only 5 mm., but in a Urus skull in the British Museum the premaxillæ extend nearly as far upwards between the nasals and the maxillæ as in the Buffalo (text-fig. 64). The extent of the connection between the premaxilla and the nasal in a Urus skull in the Anatomical Museum of the University of Edinburgh is shown in text-figs. 65 & 66.

The premaxilla is shorter and further removed from the nasal in the Bison than in any other member of the *Bos* genus (text-fig. 67). According to Major Heber Percy, the European Bison "are fond of grazing on a coarse aromatic kind of grass known as Zubr grass." Others state that "they are equally fond of browsing on the leaves, young shoots, bark, and twigs of trees," and that "in winter they are driven to subsist entirely on buds, twigs, bark, and such patches of dry grass and fern as remain" *.

The prairie Bison of America apparently fed chiefly on grass, hence doubtless the necessity for the extensive migrations, but the American woodland Bison seem to "subsist chiefly on the leaves and twigs of the birch and willow" †. It is conceivable that owing to the softer nature of the food of the Bison the necessity of having the premaxillæ firmly wedged in between the nasal and maxillary bones no longer exists.

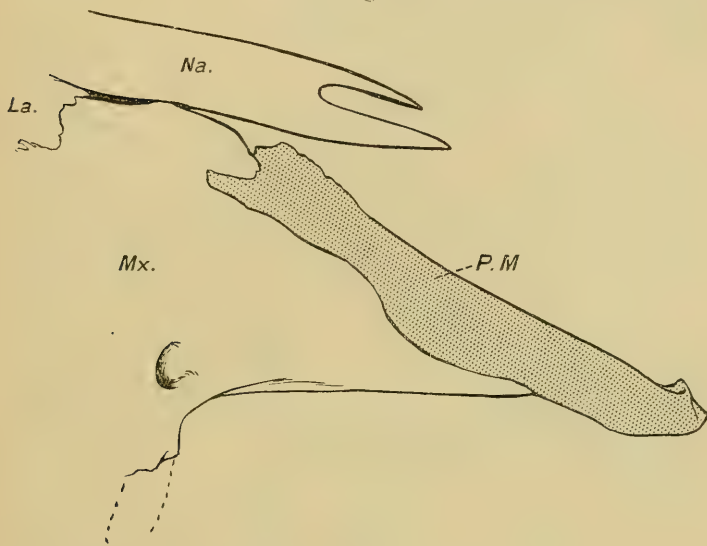
In a very young Domestic Ox skull (breed unknown) the premaxilla (text-fig. 68) bears the same relation to the nasal as in the Urus represented in text-fig. 66 ; in an older skull it occupies

* Lydekker, 'Wild Oxen, Sheep, and Cattle,' p. 77.

† Lydekker, *op. cit.* p. 91.

the angle between the maxilla and the nasal (text-fig. 69, A, B); but in a skull believed to be that of a new-born calf there is a considerable gap between the premaxilla and the nasal (text-fig. 70, A, B). In some of the skulls from the Newstead Fort the premaxillæ are large and have nearly as extensive a connection with the nasals as in the Buffalo; in others they are short and separated from the nasals by a considerable interval.

Text-fig. 73.



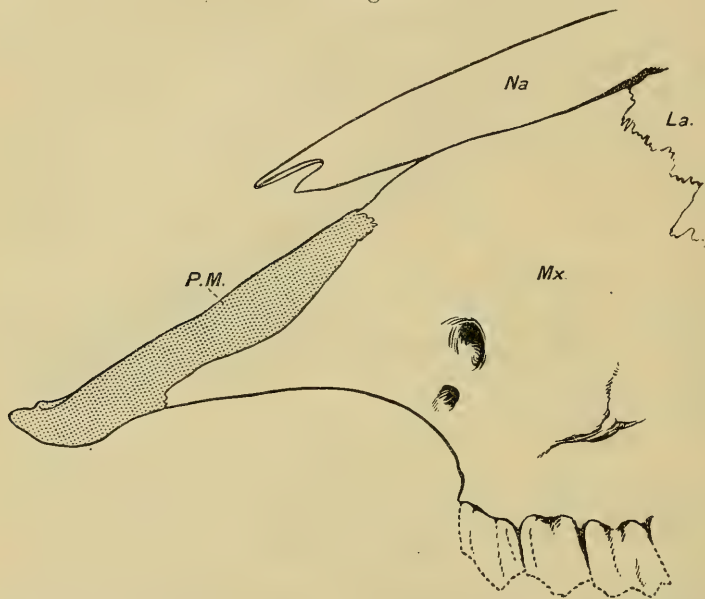
Front part of skull of polled Newstead Ox in which the upper end of the premaxillæ (*P.M.*) bifurcates.

In a Newstead polled skull the premaxillæ are long and more extensively connected with the nasals than in the Urus skull shown in text-fig. 66. In some Aberdeen-Angus cattle the premaxillæ are short, in others they are so long and so extensively connected with the nasals that they reach to within 25 mm. of the lachrymal bones (text-fig. 71); in a Buffalo with premaxillæ of the same length (text-fig. 64) the lachrymals are 75 mm. from the premaxillæ. Apparently in some Syrian cattle the premaxillæ extend well up between the maxillæ and nasals. In a skull of a Syrian Ox figured by Duerst* the premaxillæ bear the same relation to the nasals and lachrymals as in the Angus skull figured. As this Syrian Ox had small imperfect horns (text-fig. 72), and as the skull apart from the horn-cores resembles the skull of the flat-polled Angus strain, it may represent a phase in the evolution of the Aberdeen-Angus breed. The large

* Wilckens, 'Naturgeschichte der Haustiere,' p. 311, 1905.

premaxillæ, coupled with the fact that the parietal extends well on to the forehead, suggest that Aberdeen-Angus cattle have in part sprung from a race domesticated in Central Asia. While in two of the skulls of black polled Aberdeenshire cattle hitherto examined the premaxillæ have an extensive connection with the nasals, in the skull of a white polled "wild" Cadzow Ox as in a black polled Galloway, the premaxillæ bear practically the same relation to the nasals and the lachrymals as in *Bos primigenius*, represented in text-fig. 65.

Text-fig. 74.

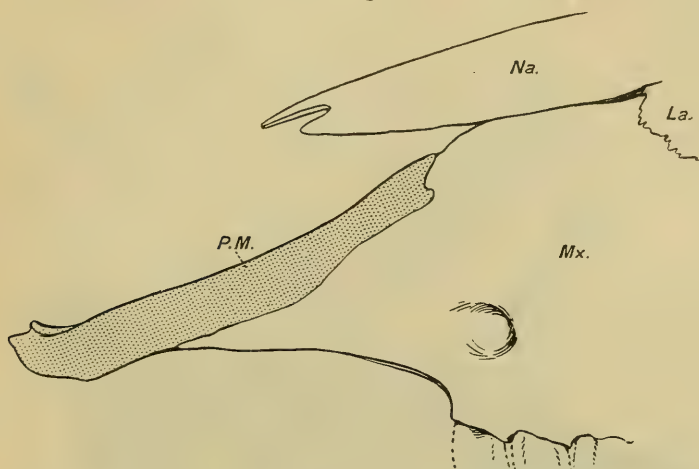


Front part of a horned Newstead skull in which the premaxillæ (*P.M.*) are short and fail to reach the nasals (*Na.*).

In most of the Newstead skulls examined the premaxillæ are absent, but when the maxillæ are present it is usually possible to say whether or not the premaxillæ had reached, or all but reached, the nasals. They probably reached the nasals in at least 90 per cent. of the skulls of the Celtic Shorthorn (*Bos longifrons*) type, and in about 70 per cent. of the skulls belonging to long-horn and cross-bred animals. In the Celtic Shorthorn skulls the premaxillæ, though long and almost in contact with the nasals, instead of ending in a wedge-shaped process, are bifurcated and send a process backwards over the maxilla as well as one upwards between the maxilla and the nasal (text-fig. 73). In having the proximal end forked the Celtic Shorthorn skulls agree with the skull of an

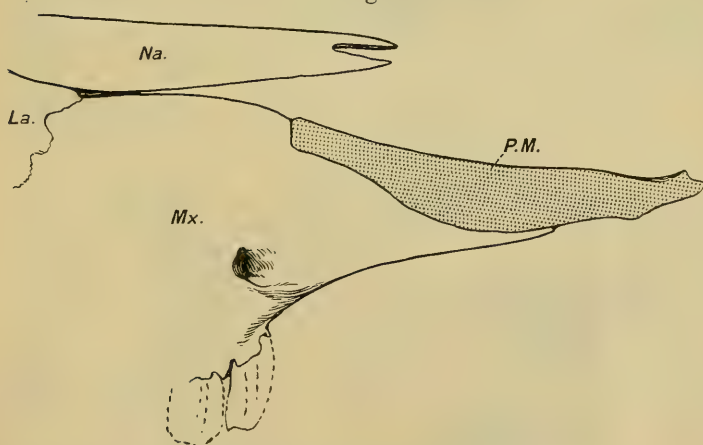
Ox from Irkutsk figured by Duerst*. In cross-bred cattle the premaxilla may be forked on the one side, as in text-fig. 73, but long and rounded on the other as in text-fig. 71.

Text-fig. 75.



Front part of skull of a horned Cadzow Ox with notched premaxillæ (*P.M.*) which fail to reach the nasals (*Na.*). From a skull in the Royal Scottish Museum.

Text-fig. 76.



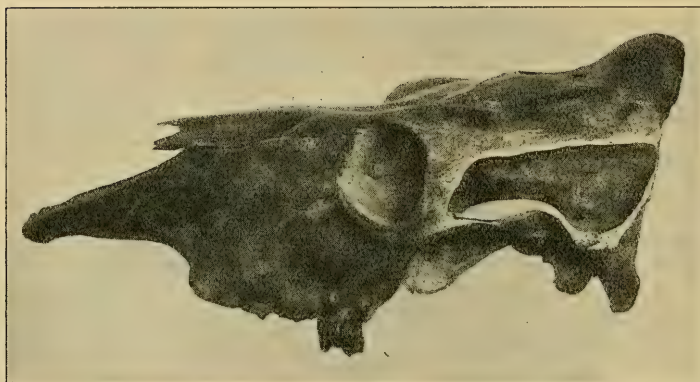
Front part of skull of cross-bred Shorthorn in which the premaxillæ (*P.M.*) fail to reach the nasals (*Na.*).

As already mentioned, Dr. Gray stated in the British Museum

* Wilkens, 'Naturgeschichte der Haustiere,' p. 305, 1905.

Catalogue of the Ungulata that in the true Oxen "the premaxillæ are large and always extend upwards between the maxillæ and nasals and consequently articulate with both these bones as in *Bubalus*." Lydekker, in discussing the premaxillæ in the Bovidæ, points out that in *Bos chinensis*, a new species described by Gray in 1870 (*i.e.* before the publication of the Catalogue of the Ungulates), "the premaxillæ are small and do not extend upwards to the nasals precisely as in *Bibos*"*. But while in *Bos namadicus* and in *Bos chinensis* the premaxillæ may be always small, they are not invariably small in the Bibovine group. In a Gaur skull in the Royal Scottish Museum the premaxillæ reach the nasals, and Mr. Pocock informs me that, of four Gaur skulls he examined

Text-fig. 77.



Skull of polled Newstead Ox with forked premaxillæ, large orbits, deeply notched occiput, uneven forehead ending in a rounded mesial prominence. Skulls of this type with horns are sometimes said to belong to *Bos frontosus* Nilsson.

in the British Museum, one has the premaxillæ in contact with the nasals, while in another skull they are separated by a long interval from the nasals. Of all Lydekker's statements about the premaxillæ, the one which bears most on the present enquiry is to the effect that a small premaxilla is "*never found in any European Ox*"†. If the premaxilla is small in *Bos namadicus*, but never small in European cattle, the presumption is that European cattle are not descended from *Bos namadicus*, but from *Bos primigenius*, in which the premaxillæ in all the skulls examined reach the nasals.

In one of the Newstead skulls, which probably belongs to an imported Ox, as large as a modern Aberdeen-Angus steer, the total length of the premaxilla is only 118 mm.—47mm. shorter than the

* Memoirs of the Geological Survey of India, series x. vol. i. p. 19.

† *Op. cit.* p. 3.

premaxilla of the Aberdeen-Angus heifer represented in text-fig. 71. The distance between the premaxilla and the lachrymal in this Newstead Ox is 80 mm., in the Aberdeen-Angus only 25 mm.

Text-fig. 78.



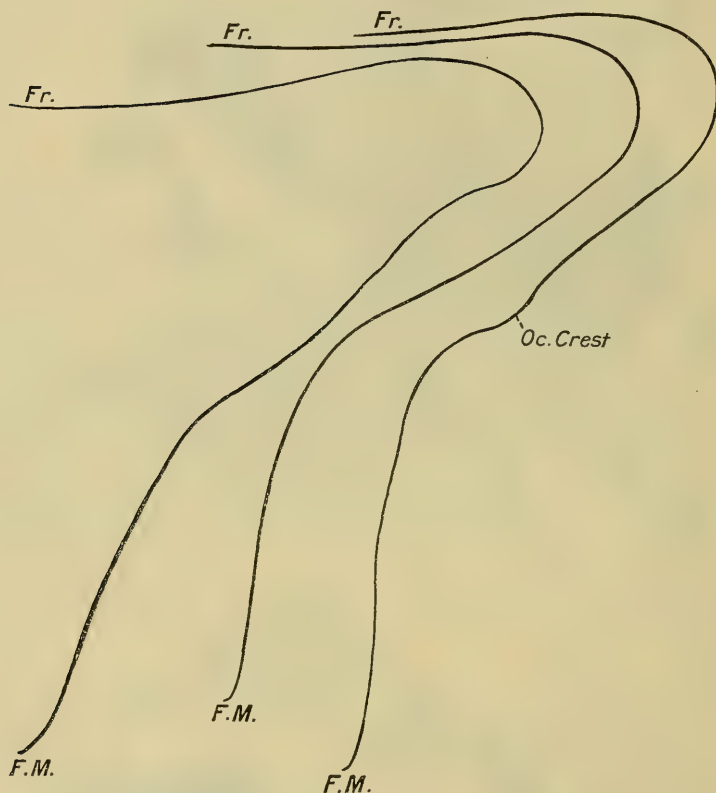
A.—Right half of occiput of the Aberdeen-Angus skull with long premaxillae (text-fig. 71, p. 258). It shows the sutures between the supra-occipital, ex-occipital, and temporal bones, and parts of the suture between the parietal and frontal.

B.—Section of **A**. The interparietal (*Pa.*) extends forwards between the frontals to form part of the forehead. The frontal sinus communicates with a large sinus in the parietal, below which is a sinus in the supra-occipital. In this skull the occiput forms a nearly right angle with the forehead. From a skull in the Royal Scottish Museum.

But in addition to being small, or rather because it is small, it fails to reach the nasal and makes no attempt to fill up the gap between

the maxilla and the nasal (text-fig. 74). As it happens, there is a skull of one of the so-called "wild" white Cadzow cattle from Hamilton Park in the Royal Scottish Museum which probably belonged to an Ox including the Celtic Shorthorn amongst its ancestors. In this Ox (text-fig. 75), though the premaxilla is 142mm. in length it neither reaches the nasal nor yet extends into the gap

Text-fig. 79.



Outlines of the occiput and part of the forehead of three Urus skulls.

Fr., frontal; *F.M.*, upper border of *foramen magnum*.

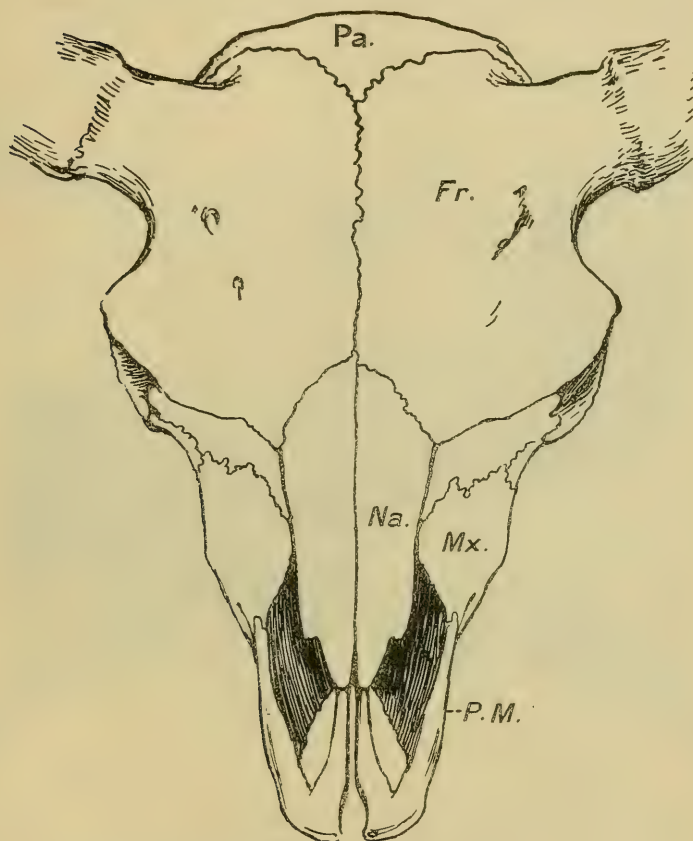
In all three skulls the intercornual ridge projects far beyond occipital condyles.

From skulls in the Anatomical, Antiquarian, and Free Church College
Museums, Edinburgh.

between the maxilla and nasal. In shape and in being notched at its proximal end, it reminds one of the premaxilla of the Celtic Shorthorn (text-fig. 73). Another skull with premaxillæ which fail to reach the nasals may be mentioned, because it has many of the

characteristics of the *Urus*. In this skull (text-fig. 76), which belonged to a cross-bred Shorthorn, the premaxilla in shape closely agrees with the premaxilla of the *Urus*, but it is relatively shorter and neither reaches the nasal nor extends into the space between the nasal and the maxilla.

Text-fig. 80.

Front view of skull of Bison (*Bos bison*).

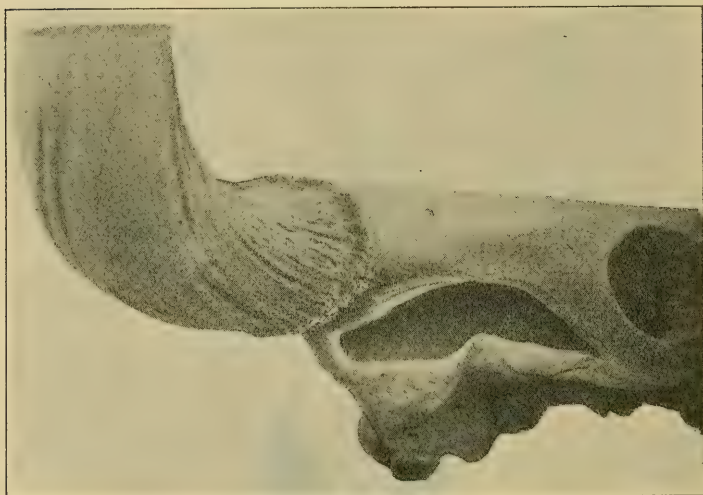
In the *Bison* the horn-cores are near the orbits, the parietals (*Pa.*) are not overlapped by the frontals (*Fr.*), and the premaxillæ (*P.M.*) are far removed from the nasals (*Na.*).

Though very few skulls have been available for study, it is evident (1) that in some modern European cattle as well as in some of the cattle in Britain during the Roman occupation, the premaxillæ were short and failed to reach the nasals, and (2) that as

the premaxillæ vary in wild as well as in domestic cattle the relation of the premaxillæ to the nasals is of little diagnostic value.

The Forehead.—In the Newstead skulls the forehead varies considerably; in some specimens it is flattened as in a typical Urus (text-fig. 66), and the ridge between the horn-cores is nearly straight; in others there are prominences and depressions and the intercornual ridge is arcuated as in some specimens of the Urus, while in a polled skull (text-fig. 77) of the *frontosus* type, the vertex projects forwards and upwards to form a well-marked rounded mesial prominence. In this polled skull there is also a projection from the middle of the forehead and a well-marked ridge at each

Text-fig. 81.



Hind part of skull of the Urus represented in text-fig. 66.

The front of the horn-core is in a line with the occipital condyle, and the temporal fossa is closed behind by a plate of bone which supports the horn-core.

side between the orbit and the long deep orbital sulcus. In old animals the parietals seem to be completely covered by the frontals. But even when the intercornual ridge projects far beyond the level of the occipital condyles the interparietal probably enters into the formation of the forehead. That the parietals (or the interparietals) form part of the forehead in polled Oxen is indicated by text-fig. 78 B, *Pa*. That in horned Oxen the parietals also enter into the formation of the forehead is suggested by a large skull of the Urus type in the Royal College of Surgeons Museum, London (No. 1121 A). In this skull the frontals are separated by a wedge-shaped piece of bone (probably the inter-

parietal), which forms the middle portion of the intercornual ridge. Oscar Schmidt* states that in a front view the parietals "cannot be seen at all," but probably in all cases the parietals in the Ox, as in the Bison (text-fig. 80), enter into the formation of the forehead. The great specialization of the frontal region of the skull in the true Oxen is made evident by the examination of foetal skulls. In a very young foetus the frontals (text-fig. 68, *Fr.*) only form the front portion of the roof of the cranium; but about

Text-fig. 82.

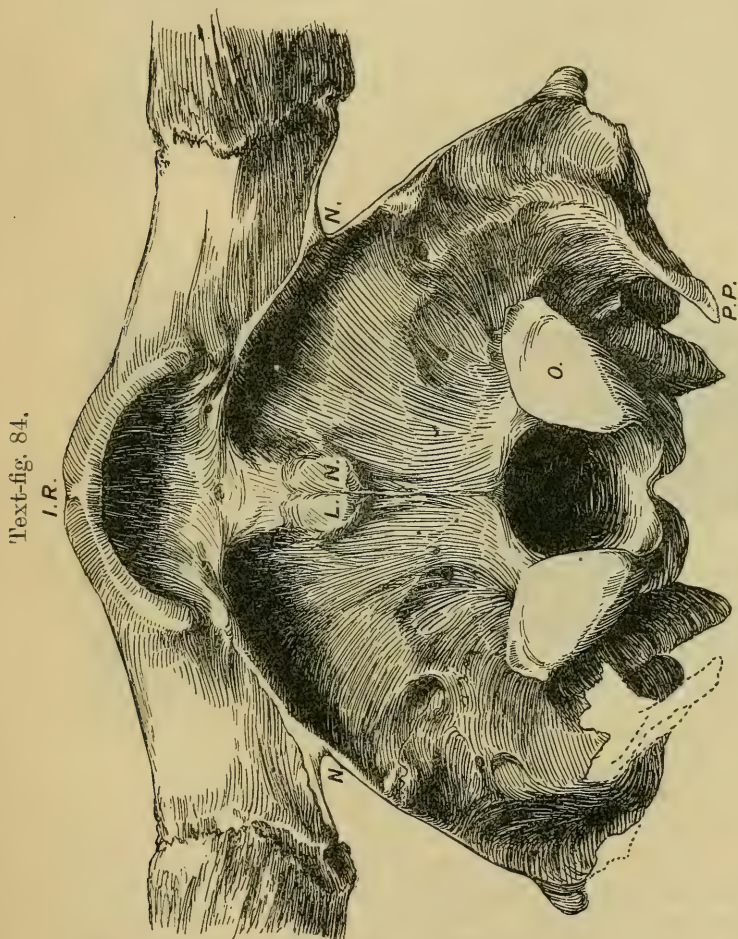


Frontlet and horn-cores of a small Newstead Ox with a prominent forehead.
The horn-cores curve upwards and backwards.

the fifth month they are relatively very much larger than the parietals (text-fig. 69, *Fr.*), and at birth they form nearly the entire roof of the cranium (text-fig. 70). After birth the frontals continue to grow backwards, and they eventually form all but the wedge-shaped middle portion of the intercornual ridge. In the Urus the frontals sometimes project 100 mm. (4 inches) beyond the occipital condyles (text-fig. 79), but in the Aberdeen-Angus the occiput almost forms a right angle with the frontals, and the

* 'The Mammalia,' p. 176.

horn-cores at their origin are far behind the most prominent part of the forehead. Moreover, the horn-cores in this case are flattened and curve outwards and backwards as in some Eastern cattle. In their position and direction the horns in this Newstead Ox decidedly differ from the horns (also of the flat type) of a Shetland heifer in my possession, which project almost directly upwards as in some Zebus.



Occiput of the Newstead skull represented in text-fig. 86, p. 274.

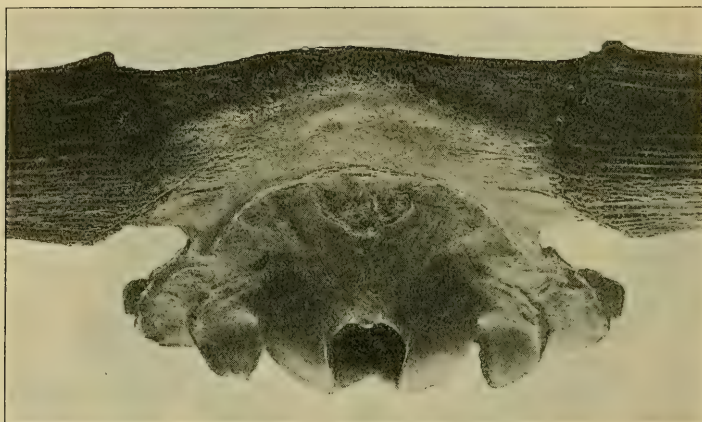
The occipital crest is rounded, and deep notches (N) separate the supra-occipital from the horn-cores. A deep semilunar depression occupies the middle of the intercornual ridge immediately above the occipital crest; O, occipital condyle; P.P., paroccipital process; L.N., surface for attachment of *ligamentum nuchae*; I.R., mesial frontal prominence.

The horn-cores are, as a rule, circular in section and, in skulls of the Celtic Shorthorn type, curve outwards and forwards nearly at a right angle to the frontals. In other skulls they curve outwards and upwards, or outwards and downwards, or outwards,

upwards, and backwards as in some Indian cattle. Except when they curve forwards at right angles to the frontals, as in typical Celtic Shorthorns, the horns assist but little in settling the race to which the Newstead skulls belong.

The Occiput.—In some Newstead skulls the occiput has the characteristics of the Urus represented in text-fig. 83. The general outline is quadrangular, the occipital crest is flattened but not encroached on by the temporal fossæ, the lateral borders are nearly straight, and a line carried through the highest point of the crest lies below the centre of the horn-cores; further, there is a shield-like projection (*L.N.*) for the insertion of the ligamentum nuchæ. The distance from the crest to the lower border of the foramen magnum is nearly the same as the distance between the condyles (*C.*) and little more than half the distance between the notches (*N.N.*) below the horn-cores on a level with the temporal fossæ.

Text-fig. 85.



Occiput and horn-cores of a Urus in which the notches below the horn-cores are deeper than in text-fig. 83.

This occiput closely resembles the occiput of a *Bos namadicus* skull in the British Museum.

The nearly smooth supracristal part of the occiput extending between the horn-cores measures from above downwards about half as much as the part lying between the crest and the lower border of the *foramen magnum*. In some cases the supracristal part is flat and nearly in a line with the occiput proper, in others it projects beyond the crest (text-fig. 79) and, though concave in the centre immediately over the shield for the ligamentum nuchæ, it is prominent and convex above and forms a marked angle with the forehead. In some cases the upper border of the

occiput viewed from behind is nearly straight, in others it is slightly concave or distinctly arcuated.

In specimens of the Urus with very thick horn-cores a bridge of bone extends downwards from the base of the horn-core and forms a posterior wall for the temporal fossa (text-figs. 81 & 83, *N.*), which completely cuts off the fossa from the occiput. It is owing to the temporal fossæ being closed in behind by extra supports for the horn-cores that the width of the occiput immediately below the horn-cores is sometimes nearly twice as much as the distance between the crest and the lower border of the *foramen magnum*.

Though in the majority of the Newstead skulls the occiput conforms to the Urus type there are several with short premaxillæ in which the occiput reminds one of Lydekker's *Bos acutifrons*. Writing in 1880 Lydekker pointed out that *Bos acutifrons* of the Punjab Siwaliks had no marked relationship to any existing species and was "widely different in the form of its occiput, frontals, and horn-cores from *Bos primigenius*"*.

Though Rüttimeyer and others regarded *Bos planifrons* and *Bos acutifrons* as varieties of a species closely allied to *Bos primigenius*, no skulls of true Oxen have hitherto been described in which the occiput resembles that of *Bos acutifrons*.

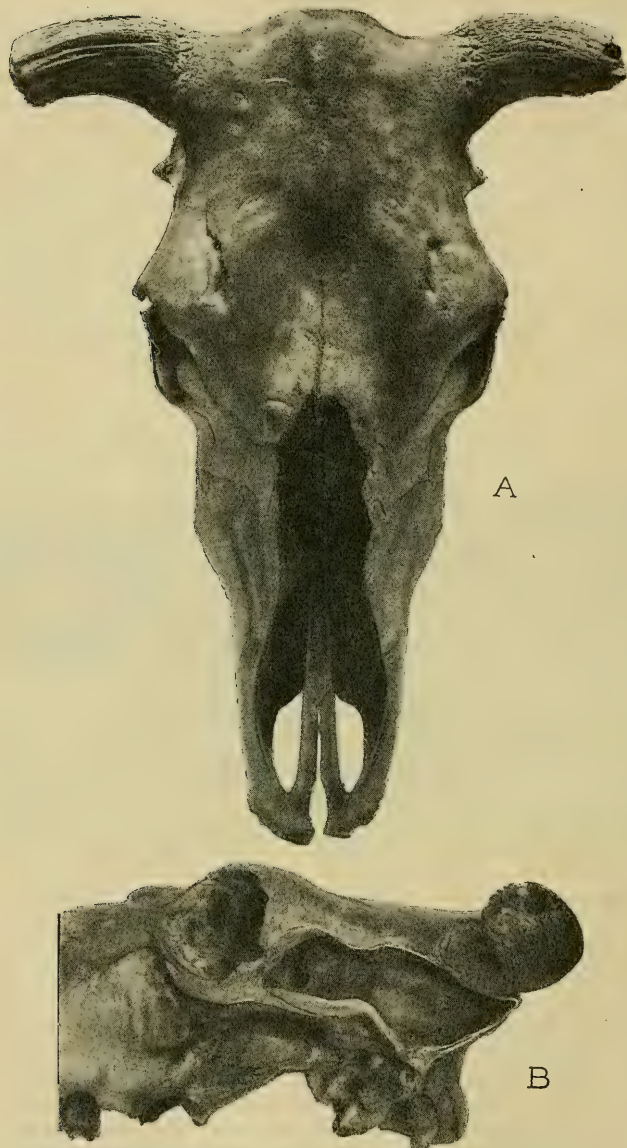
In *Bos namadicus*, as well as in *Bos primigenius*, the notches below the bases of the horn-cores are shallow, but in the Newstead skull represented in text-fig. 84 indentations or notches (*N.*) below the horn-cores are so deep that the connection between the upper (parieto-frontal) part of the occiput and the lower (infra-cristal) part is relatively short. Because of these indentations the occiput viewed from behind (text-fig. 84) bears a resemblance to that of the Gaur (*Bos gaurus*).

In *Bos primigenius* the summit of the occipital crest is on a lower level than the middle of the horn-cores (text-fig. 83), but in the Newstead skull of the *acutifrons* type a line carried through the summit of the rounded arch formed by the occipital crest (text-fig. 84) passes above the middle of the horn-cores.

At the widest part the occiput of the first century skull (text-fig. 84) measures 215 mm., and from the lower border of the *foramen magnum* to the occipital crest the distance is 115 mm. The depth (115) multiplied by 100 and divided by the width (215) gives an index of 53·5. In the Urus represented in text-fig. 85 the corresponding index is 47. Between the notches under the horn-cores the distance in the Newstead skull (text-fig. 84) is 123 mm.: $123 \times 100 \div 215$ (the total width of occiput) gives an index of 57; in the Urus, owing to the shallowness of the notches under the horn-cores, the corresponding index may be 90. The distance (115 mm.) between the lower border of the *foramen magnum* and the occipital crest multiplied by 100 and divided by the distance (123 mm.) between the infracornual notches gives an index of 93·5; the corresponding index in the Urus may be only 52·4.

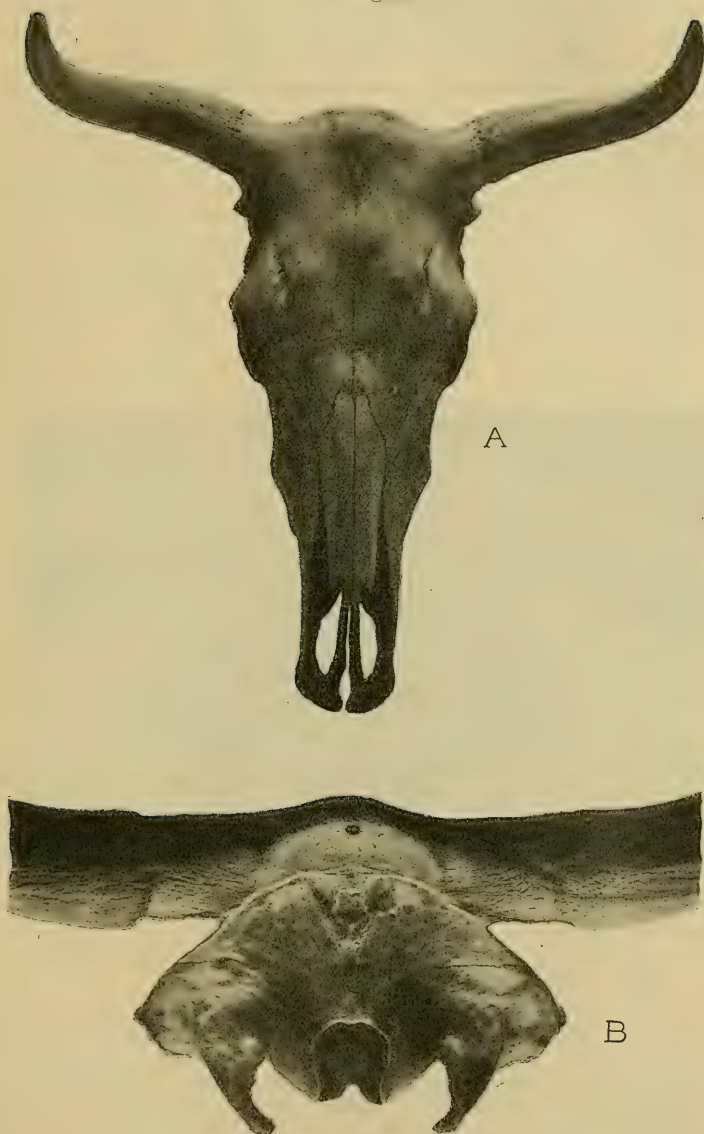
* Memoirs of the Geological Survey of India, series x. vol. i. p. 2.

Text-fig. 86.



- A.**—Front view of the Newstead skull of which the occiput is represented in text-fig. 84, p. 271.
- B.**—Temporal fossa of above skull. The fossa communicates freely with the occiput. Compare with fossa of the *Urus* (text-fig. 81, p. 268).

Text-fig. 87.



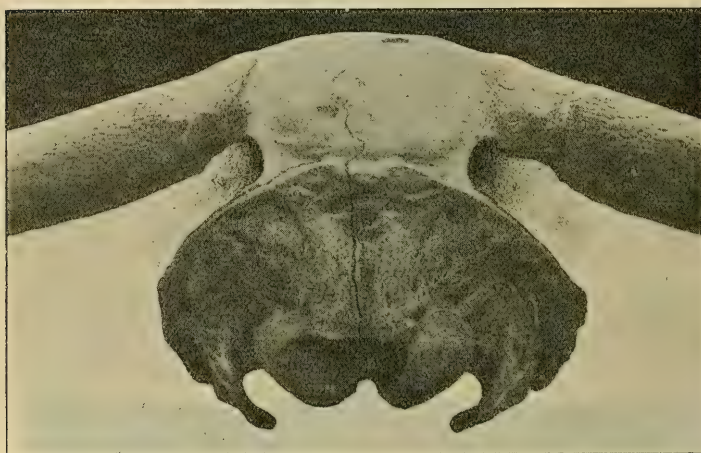
A.—Front view of a white “wild” Cadzow Ox from Hamilton Park.

B.—Occiput and horn-cores of the above skull.

This skull closely resembles the Newstead skull (text-figs. 84 & 86) with a deeply notched occiput. From a specimen in the Royal Scottish Museum.

From the narrow shield-shaped projection (*L.N.*) under the crest (text-fig. 84), a narrow ridge extending towards the *foramen magnum* divides the lower part of the occiput into two equal portions roughened for the attachment of muscles. Between the crest and the upper border of the *foramen magnum* the occiput is distinctly concave—near the crest it is excavated to a depth of 12 mm. The part of the occiput external to the condyles (*C.*) is divided by a ridge continuous with the incurved paroccipital processes (*P.P.*) into two irregular, more or less concave, rough surfaces. The greatest width across the occipital condyles (*C.*), is 99 mm. (only 23 mm. less than the space between the infracornual notches): $99 \times 100 \div 123$ (the width of the occiput under the horn-cores) gives an index of 80. The corresponding index in the *Urus* skull (text-fig. 83) is only 55.

Text-fig. 88.



Occiput and horn-cores of an American Bison.

The frontals neither cover the parietals (text-fig. 80, p. 267) nor project beyond the level of the occipital crest, and the horn-cores are separated by wide gaps from the supra-occipital.

The part of the occiput above the occipital crest is divided into three portions, viz.:—a mesial semicircular deeply excavated portion and two lateral portions continuous with the horn-cores externally and the forehead above. The mesial semicircular concave portion (text-fig. 84), 60 mm. wide and 20 mm. deep, has a rough margin, 3 to 6 mm. in thickness, which forms the nearly horizontal border of the mesial frontal protuberance (text-fig. 86, A).

From the measurements given it follows that the occiput of

the Newstead skull (text-fig. 84) differs profoundly from that of the more highly specialized Urus skull represented in text-fig. 83.

The Horn-cores.—The horn-cores of the Newstead skull, characterized by a deeply notched occiput, are pyriform as in *Bos acutifrons*—they measure at their origin 60 mm. from above downwards and 45 mm. from before backwards. At a distance of 30 mm. from the beginning of the grooved surface they measure 56 mm. by 42 mm. The fragments of the horn-cores present (text-fig. 86, A) are convex above, grooved in front and below, and extend outwards and slightly forwards.

The Temporal Fossa.—In the Urus skull figured the temporal fossa is completely closed behind (text-fig. 81) by a wall of bone which helps to support the horn-core (text-fig. 83); the external opening of the fossa, rounded and contracted behind, is pointed in front and arched above (text-fig. 81). In the Newstead skull with short premaxillæ and a notched occiput, the temporal fossa is wide behind, where it opens on to the occiput, wider than in the Urus in front, and the upper border is sinuous (text-fig. 86, B) as in the Bison.

The Base of the Cranium.—In the Urus the anterior as well as the posterior tubercles are well developed, but in the Newstead skull (text-fig. 84), as in *Bos acutifrons*, the anterior tubercles are small and inconspicuous.

In having the lower part of the occiput separated from the upper by deep notches under the horn-cores the Newstead skull (text-fig. 84) decidedly differs from *Bos primigenius* (text-fig. 83) and also, though to a less extent, from *Bos namadicus*. Again, in having the occipital crest overhanging the true occiput, the Newstead skull differs from the Gaur and Banting.

If Lydekker is right in assuming that the occipital crest in *Bos acutifrons* "extends upwards to within a short distance of the *vertex cranii* so that the supra-cristal portion of the occipital region is reduced to a very narrow band"*, the Newstead skull also differs from *Bos acutifrons*. If, however, in *Bos acutifrons* the mesial depression immediately below the vertex is supra-cristal, the Newstead skull with a deeply notched occiput may be regarded as belonging to a race allied to, or descended from, *Bos acutifrons* of the Punjab Siwaliks.

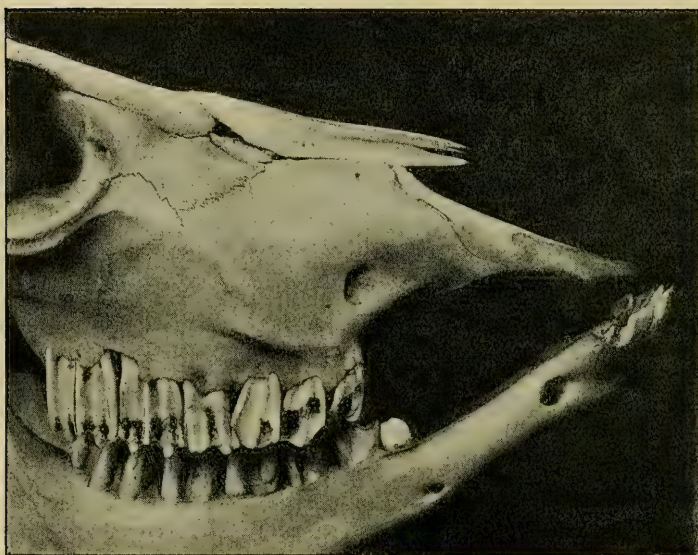
It will doubtless be asked, Are any of the modern breeds of cattle characterized by short premaxillæ and an occiput of the primitive type represented in text-fig. 84? As it happens, the skull (text-fig. 87) of the white "wild" Cadzow Ox with short premaxillæ (text-fig. 75) has an occiput (text-fig. 87, B) of the *acutifrons* type, and otherwise resembles several of the Newstead skulls. The skull of the Cadzow Ox seen from behind looks almost as if it were intermediate between the Bison (text-fig. 88) and a Urus with fairly deep notches (text-fig. 85).

At one time the Hamilton Park herd of white cattle consisted

* Memoirs of the Geological Survey of India, ser. x. vol. i. p. 27.

almost entirely of polled individuals, now they are said to be all horned *. There is a tradition that Cadzow cattle re-acquired horns through a Highland bull, which, for a time, took forcible possession of the herd, and it is a matter of history that some years ago a "wild" Chillingham bull was made use of to reinvigorate the Cadzow "wild" cattle. The intercrossing, perhaps, led to reversion towards a race in the possession of, if not actually introduced by, the Roman auxiliaries who garrisoned the border-fort during the later part of the first century †.

Text-fig. 89.



Front part of the skull of a Zebu (*Bos indicus*) in which the premaxillæ reach the nasals.

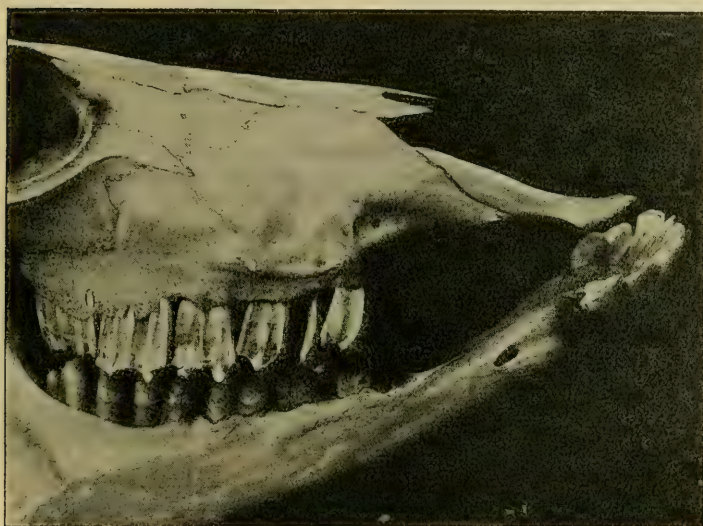
In addition to Newstead skulls with an occiput of the Urus and *acutifrons* types, there are skulls which in the occiput agree with certain Indian cattle. In Indian as in European domestic cattle the premaxillæ are sometimes long and in contact with the nasals (text-fig. 89), sometimes short and terminating some distance from the nasals (text-fig. 90). In at least some Zebras long premaxillæ are correlated with a wide Urus-like occiput, and short premaxillæ with a narrow deep occiput. In several small Newstead skulls the occiput closely

* A skull of a polled Cadzow Ox in the Anatomical Museum of the University of Edinburgh agrees in the premaxillæ and occiput with *Bos primigenius*.

† The Chillingham and Chartley "wild" park cattle in their occiput conform to the Urus type.

agrees with a Zebu skull (text-fig. 91) in the Royal College of Surgeons Museum, London. In *Bos primigenius* the shield-like projection for the *ligamentum nuchæ* is in contact with the occipital crest, but in some of the small Newstead skulls, as in the skull of the *acutifrons* type, the rough surface for the attachment of the *ligamentum nuchæ* lies, as in some Zebus, nearly midway between the occipital crest and the upper border of the *foramen magnum*. Further inquiry may show that Indian domestic cattle are in part descended from ancestors allied to Lydekker's *Bos acutifrons* and that the Celtic Shorthorn (*Bos longifrons* Owen, *Bos brachyceros* Rütimeyer) is intimately related to some of the small Oriental races.

Text-fig. 90.



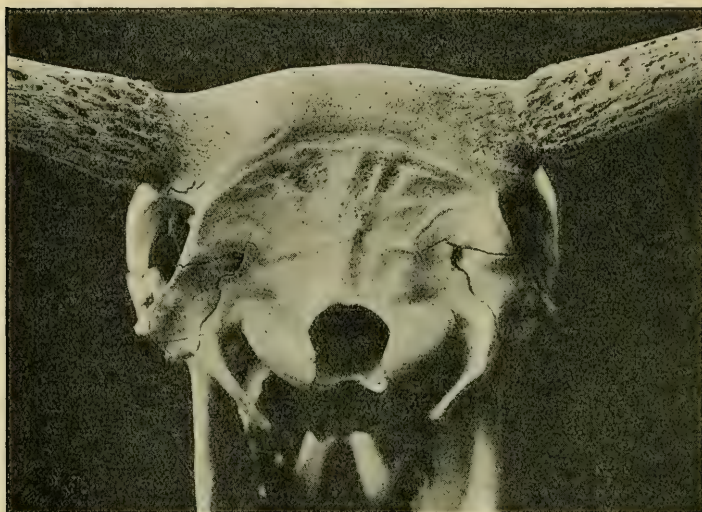
Front part of the skull of a Zebu in which the premaxillæ fail to reach the nasals.

The Origin of the Newstead Oxen.

In addition to cross-bred animals Newstead has yielded five fairly distinct types of Oxen, viz.:—(1) Oxen of the Celtic Shorthorn type; (2) Long-horned Oxen of the Urus type; (3) Oxen with an occiput of the *Bos acutifrons* type; (4) Oxen with a convex forehead, an arcuated intercornual ridge and horns curving outwards and backwards; and (5) Hornless Oxen. It is impossible to say definitely how any of these forms originated, but it may be safely assumed that they were not all formed in Europe from *Bos primigenius*.

Though *Bos primigenius* reached Europe from Central Asia in early Pleistocene times, there is no evidence that it was living under domestication on the arrival in Post-Pleistocene times of the Neoliths. Further, there is no evidence of the existence of a small Ox of the Celtic Shorthorn type in European Palaeolithic deposits—Prof. Boule *e. g.*, found not a single fragment of Owen's *Bos longifrons* in deposits of the Reindeer age at Monaco. Neither is there any evidence of the existence of a small wild Ox in Pleistocene times in Central Asia.

Text-fig. 91.



Occiput of the Zebu with the premaxillæ reaching the nasals (text-fig. 89).

In several of the Celtic Shorthorn skulls from Newstead the occiput resembles that of the Zebu.

Text-figs. 89-91 from skulls in the Royal College of Surgeons Museum, London.

The examination of the bones of Oxen from Anau, Turkestan, led Duerst to conclude:—(1) that a large long-horned breed was formed by the Anau-li about 8000 B.C. from a large wild Asiatic race which he regarded as the exact equivalent of the European Urus (*Bos primigenius*); (2) that about 6000 B.C. a small short-horned breed, identical with Owen's *Bos longifrons* and Rüttemeyer's *Bos brachyceros*, was formed at Anau, or brought to Anau from some other settlement in Central Asia. If, as seems probable, the Urus was the only wild Ox in Central Asia in prehistoric times, it must be assumed that the small Ox in the

possession of the Anau-li was a dwarfed descendant of an Asiatic variety of *Bos primigenius**.

It is doubtless possible that a small breed may have been formed out of the huge Urus by the Neoliths immediately after they reached Europe, but the evidence, so far as it goes, suggests that the Neoliths brought the "Celtic" Shorthorn with them from Central Asia.

Though in Britain the Urus was hunted by the Neoliths—evidence of this we have in the Urus skull from Burwell Fen, near Cambridge, with the frontals pierced by a Neolithic flint implement—there is no evidence that *Bos primigenius* was once domesticated in Britain or that the Neoliths allowed their domestic cattle to breed with young wild bulls.

But on the Continent the Urus was apparently domesticated at a comparatively early period and crossed with the small breed originally brought from Central Asia. Hence it may be said that up to at least the Bronze age the majority of the domestic cattle in Europe were the descendants of *Bos primigenius*—some being nearly pure descendants of the imported "Celtic" Shorthorn breed, while others were pure or nearly pure descendants of the indigenous wild Urus (*Bos taurus primigenius*).

There is no evidence that there existed in Europe or in Central Asia a variety of *Bos primigenius* with the occiput deeply notched and otherwise resembling the one represented in text-fig. 84. Neither is there any evidence that in *Bos namadicus*—the Urus of India—the occiput was deeply notched or characterized by an excavated intercornual ridge. The only extinct form to which the Newstead skull represented in text-figs. 84 and 86 bears any marked resemblance is *Bos acutifrons* of the Pliocene Siwaliks. It has been suggested that the Newstead skull with a deep mesial semicircular depression above the occipital crest belonged to a hybrid between an Ox and a Bison, but this view is not supported by the skulls of Ox-Bison hybrids. Moreover, in its occiput and premaxillæ this Newstead skull (text-figs. 84 & 86) very closely agrees with the skull of a Cadzow Ox (text-fig. 87) in the Royal Scottish Museum. It may hence in the meantime be assumed that some of the cattle in the south of Scotland during the Roman occupation were descended from an Indian race allied to *Bos acutifrons*.

Of the Newstead cattle with horns curving backwards and downwards (text-fig. 82) it need only be said that they seem to be more intimately related to *Bos namadicus* than to *Bos primigenius*.

The polled Newstead cattle represent two distinct types. Some had a nearly flat forehead, a nearly straight "intercornual" ridge, and a square-shaped occiput; in others the forehead was very uneven and ended in a pronounced mesial prominence which projected upwards and forwards (text-fig. 77). The Newstead

* The small Ox of Anau is probably now represented in Asia by the long-browed Zebu characterized by small horns of the *Bos longifrons* type.

cattle with a flat poll (as in the modern Galloway and in polled Cadzow cattle) obviously belong to the Urus type, while those with a mesial prominence seem to belong to the *frontosus* type of Nilsson. As there were hornless cattle in Egypt as early as the Fourth Dynasty, we are not likely soon to ascertain where or when polled breeds originated. There is no evidence that any of the varieties of polled cattle are descended from hornless wild ancestors; neither is there certain evidence of a pure horned race suddenly producing polled offspring. If, as seems highly probable, the absence of horns is not due to reversion, the polled condition was either acquired by the gradual reduction in the size of the horns or suddenly, *i. e.* by mutation. In polled breeds which now and then produce individuals with "loose horns" the polled condition was perhaps acquired slowly, while in polled breeds in which "scurrs" are unknown the polled condition was perhaps due to a mutation. Though the Galloway and the white polled "wild" Cadzow cattle may have descended from *Bos primigenius*, the white polled Somerford, and the round polled Aberdeen-Angus cattle with the premaxillæ extending well up between the maxillæ and nasals, may be the descendants of an Oriental race allied to a modern Syrian breed apparently in the act of losing the horns.

13. Plankton from Christmas Island, Indian Ocean.—I. On Copepoda of the Family *Corycæidæ*. By GEORGE P. FARRAN*.

[Received October 31, 1910: Read February 7, 1911.]

(Plates X.—XIV. †)

Through the kindness of Dr. W. T. Calman I have had the opportunity of examining the Copepoda of a small collection (8 bottles) of Plankton, made by Sir John Murray, K.C.B., F.R.S., and Dr. C. W. Andrews, F.R.S., at Christmas Island in the Indian Ocean, and presented to the British Museum by Sir J. Murray.

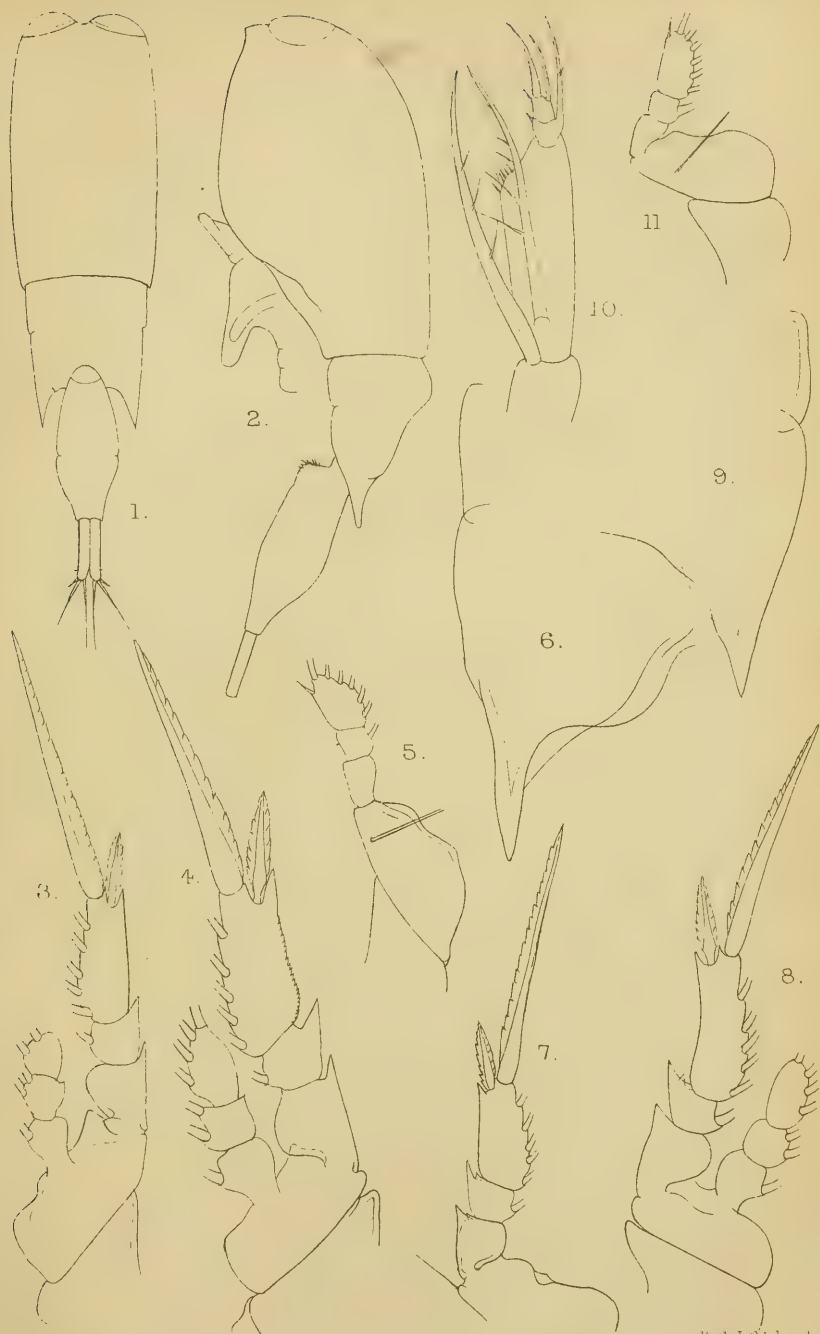
The gatherings were all made at approximately the same time (July–August, 1908) and in the same locality, on the north side of the island in shallow water near shore, and for this reason it has not been thought necessary to refer to each of them separately.

The collection, though small in bulk, is exceedingly rich in species, and the genus *Corycæus* is especially well represented.

It has been recognized that there are, in the the genus *Corycæus*, two groups differing from each other in several distinct characters, the most notable being the form of the ventral process, situated between the maxillipedes and the first pair of

* Communicated by Dr. W. T. CALMAN, F.Z.S.

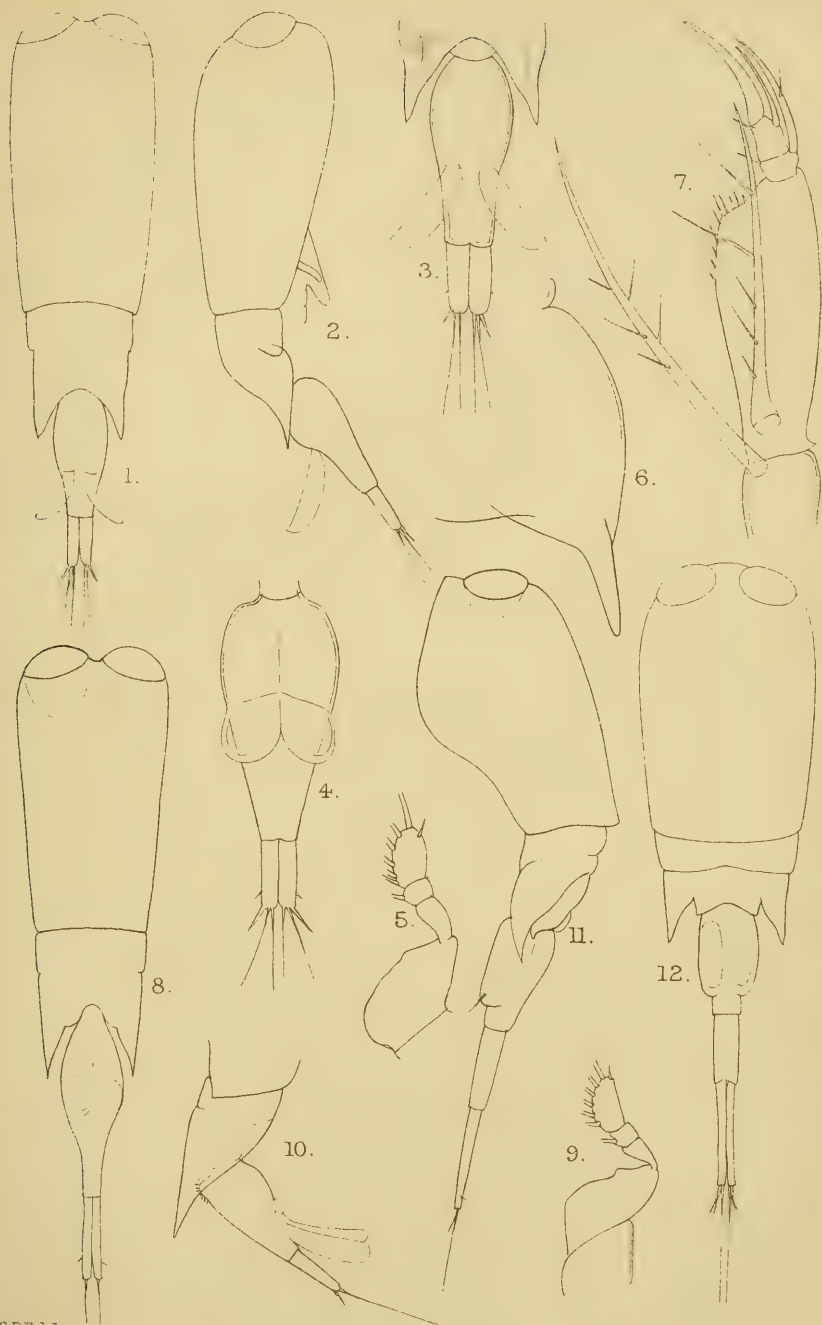
† For explanation of the Plates see p. 296.



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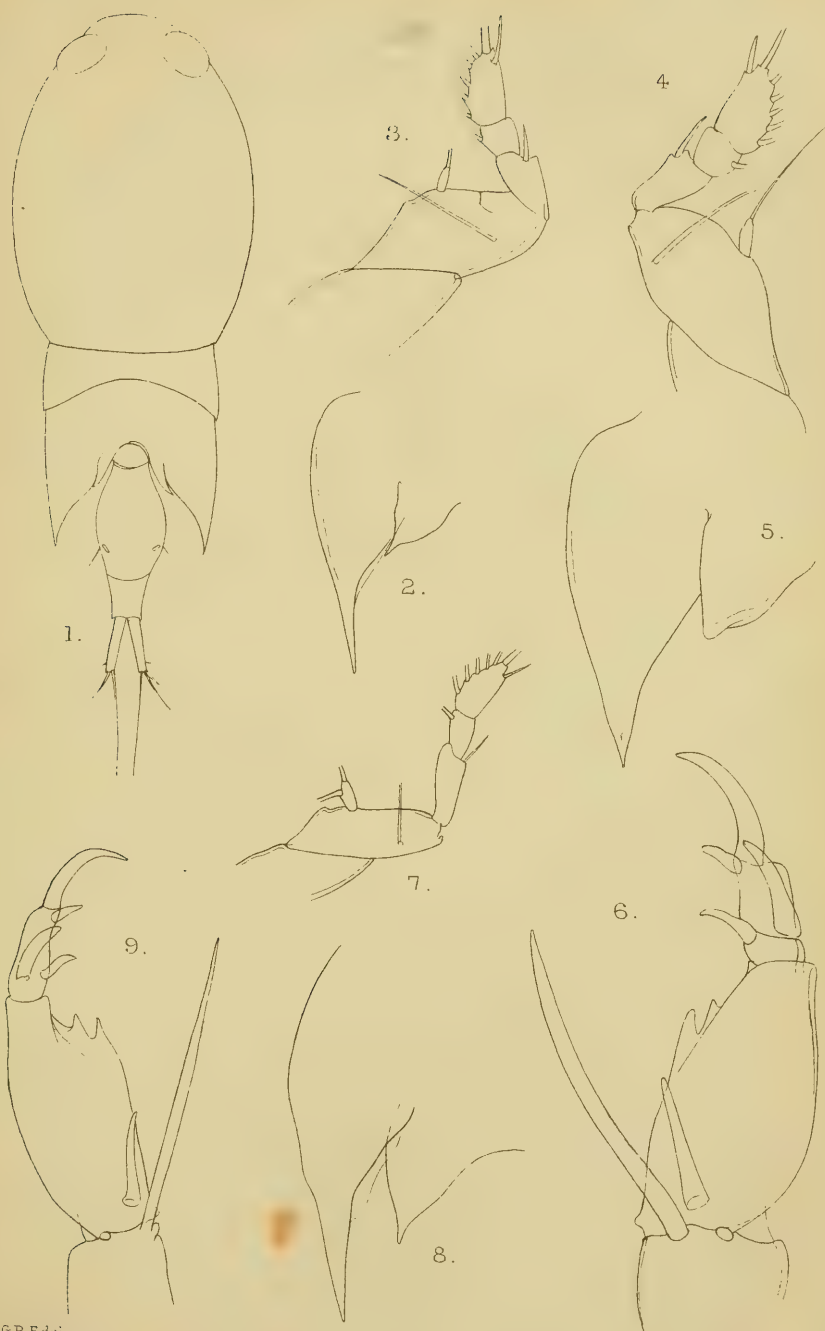
1—6. *CORYCELLA BREVIS*.
7—11. *CORYCELLA CURTA*.



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Hughes London.

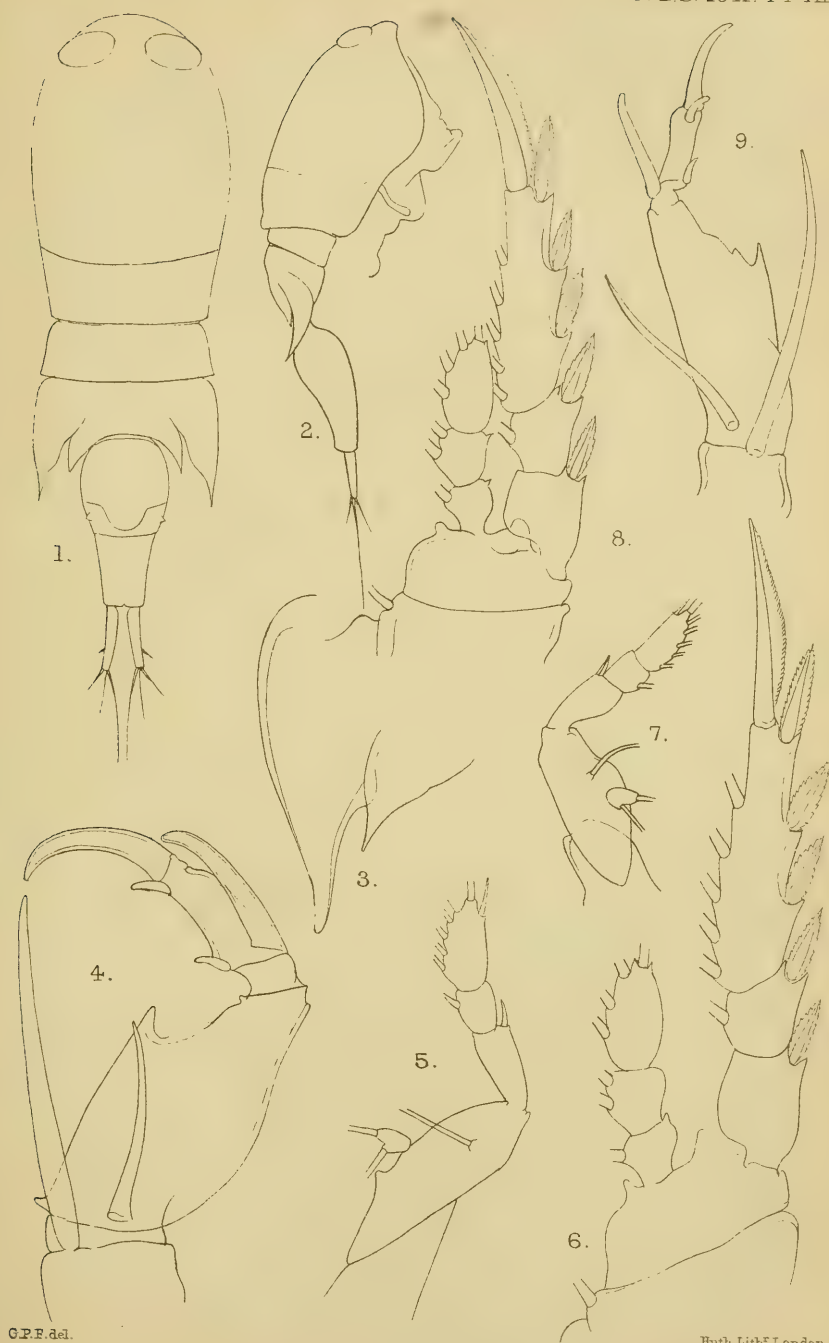
1-6. *CORYCELLA CURTA*. 7. *C. BREVIS*.
 8, 9. *CORYCELLA* sp. ♂ 10. *C. CARINATA*.
 11, 12. *CORYCAEUS GRACILICAUDATUS*.



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Huth, Lith. London.

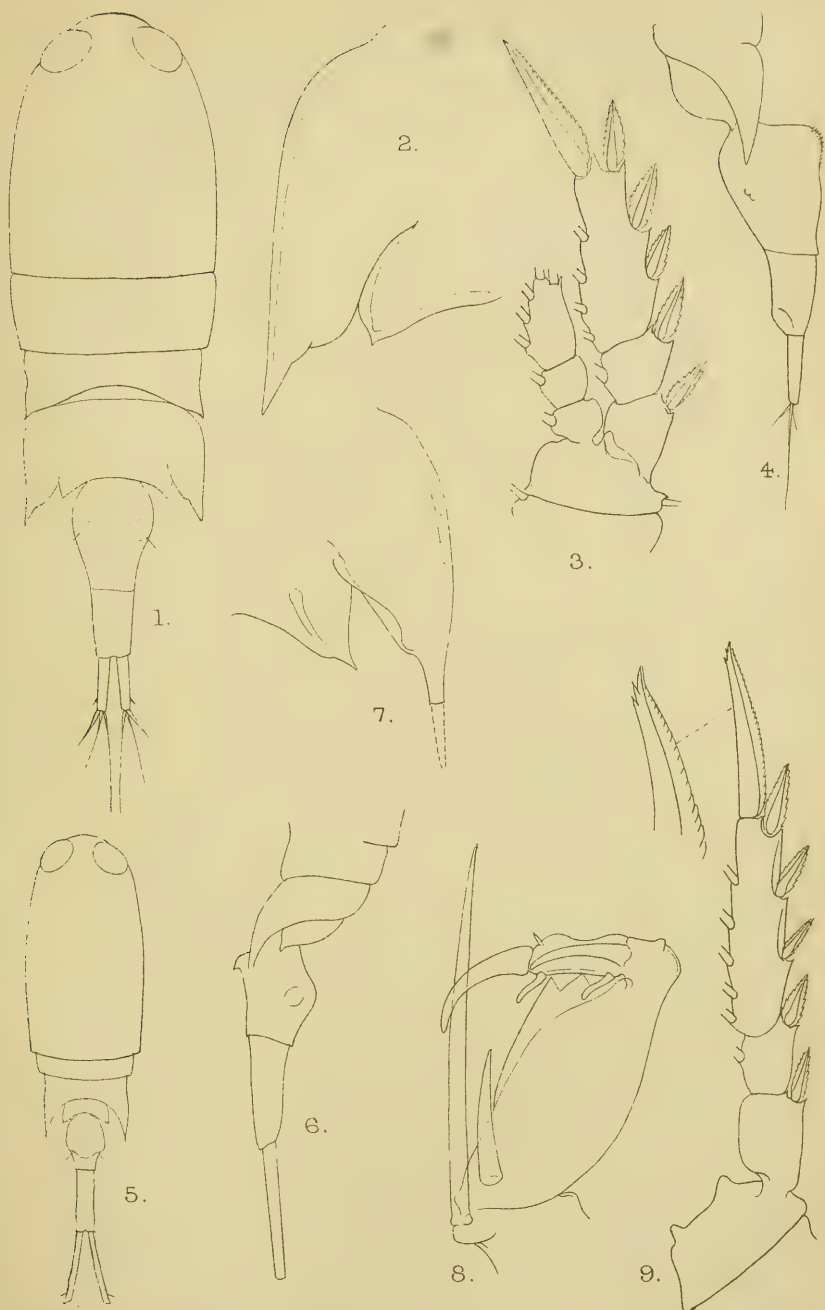
1—3. *CORYCAEUS CATUS*. 4—6. *C. OBTUSUS*
7. *C. DUBIUS*. 8. 9. *C. TENUIS*.



G.P.F. del.

Huth, Lith^r London.

1-6. *CORYCAEUS MURRAYI*.
7-9. *C. ANDREWSI*.



G.F.F. del

1-4. CORYCAEUS ANDREWSI.
5-9. C. DUBIUS.

Huth, Lith^r London.

feet of the female, which is beak-shaped in one group and semi-circular in the other. There can be no doubt that these characters are, collectively, of generic importance, and I propose the name *Corycella* for that subdivision, as typified by *C. gibbulus*, which is marked by the possession of a beak-shaped ventral process, leaving the name *Corycæus* for the remaining species, of which *C. speciosus* may be selected as the type.

The genus *Corycæus* was founded by Dana in 1845 (6), his diagnosis being repeated in 1846 (7), but no species belonging to the genus was described till 1849 (8). Dana's definition of the genus includes both the genera defined above, and his papers describing the species, first published without figures in 1849 (8), and afterwards with figures in 1852 (9), contain forms belonging to both *Corycella* and *Corycæus*, but do not indicate any one of them as forming the type of the genus.

The principal differences between *Corycæus* and *Corycella* may be summarized as follows:—

Genus *CORYCELLA*, nov.

Abdomen of ♂ and ♀ one-jointed; 4th thoracic segment without lateral points, not distinct from 3rd thoracic segment. Ventral process beak-shaped in ♀. 2nd antenna with setæ on 1st and 2nd basal joints distantly feathered; terminal spine short in ♂; inner edge of 2nd basal coarsely feathered.

1st to 3rd feet, exopodite with 0.0.1 outer edge setæ.

4th foot without endopodite, exopodite with 0.0.1 outer edge setæ.

Genus *CORYCÆUS* Dana.

Abdomen of ♂ and ♀ usually two-jointed; 3rd and 4th thoracic segments distinctly separate, the latter with lateral points. Ventral process semi-circular in ♀. 2nd antenna with the setæ on 1st and 2nd basal joints not feathered; terminal spine elongated in ♂, inner edge of 2nd basal usually with one or more strong teeth.

1st to 3rd feet, exopodite with 1.1.3 outer edge setæ.

4th foot with endopodite bearing one or two setæ, exopodite with 0.1.1 outer edge setæ.

The one-jointed abdomen and the feathered setæ of the second antennæ occur, as Dahl has pointed out, as characters of immaturity in the genus *Corycæus*.

Giesbrecht (10) recognises five species of *Corycæus* in the group for which the name *Corycella* is proposed, viz., *C. gibbulus* Giesbr., *C. concinnus* Dana, *C. rostratus* Claus, *C. carinatus* Giesbr., and *C. longicaudis* Dana.* In Dahl's revision of the genus (5) he accepts *C. gibbulus*, *C. concinnus*, *C. carinatus*, *C. rostratus*, and, under the new name of *C. tenuicauda*, *C. longicaudis*, asserting that Dana's description of *C. longicaudis* really refers to *C. speciosus* juv., a view which is strongly supported by Dana's figures. Dahl also recognises Dana's (8) description of *C. gracilis* as being good, but does not give any reason for this opinion. Dana's description and figures of *C. gracilis* evidently refer to a male of *Corycella*, but the specific differences between the males of this genus are so slight that it does not appear possible to refer the description and figures with certainty to any particular species. Dahl's belief that *C. pellucidus* of Dana is the female of what he recognises as *C. gracilis* also appears to be a mere conjecture, there being very little evidence for or against

the view in Dana's figures, which, apparently, include two different species.

Wolfenden (11) also believes that he has recognised the *C. pellucidus* of Dana, but his figures and descriptions refer undoubtedly to the species which Giesbrecht has described as *C. gibbulus*.

Dahl, in the paper referred to above (5), which is a preliminary note on the Copepoda of the Plankton Expedition, has drawn up a useful diagnostic table of the members of the genus *Corycæus* as recognised by him. The portion which refers to the genus *Corycella* has been translated by Dr. Wolfenden (11) in his account of the Maldivé Copepoda. In this table Dahl gives as a mark to distinguish the other members from *C. rostratus*, "Viertes Beinpaar mit einem inneren Zapfen welcher eine Borste trägt." If by "Zapfen" is meant endopodite, as is undoubtedly the case in the latter part of the table, and as Wolfenden translates it, this statement is an error, as the endopodite is absent throughout the group. There is a mistranslation in Wolfenden's table which detracts somewhat from its usefulness; the sentence "Genital openings of ♀ set at end of abdomen" should read "distant from end of abdomen," "vom Ende des Abdomens entfernt."

The specific characters in the genus *Corycella* are very slight and depend mainly on the shape of the abdomen and the third thoracic segment. The following is an attempt to draw up a diagnostic table, to include the females of which a recognisable description exists and two new species from the Christmas Island collection, which are described below.

- | | |
|---|---------------------------|
| 1. Furca only twice as long as broad..... | <i>C. rostrata</i> . |
| 2. Furca three or more times as long as broad. | |
| A. Furca shorter than widest part of abdomen in dorsal view. | |
| a. Widest part of abdomen behind the middle, 3rd thoracic segment with dorsal hump. | |
| a. Abdomen less than twice as long as high in lateral view, median furcal spine short and stout | <i>C. gibbula</i> . |
| β. Abdomen ca. $2\frac{1}{2}$ times as long as high in lateral view, median furcal spine slender..... | <i>C. brevis</i> , sp. n. |
| b. Widest part of abdomen in front of middle, 3rd thoracic segment not humped dorsally. | |
| a. Thoracic spines long, abdomen with ventral setose pad | <i>C. carinata</i> . |
| β. Thoracic spines short, abdomen without setose pad ... | <i>C. curta</i> , sp. n. |
| B. Furca longer than widest part of abdomen. | |
| a. Furca less than half as long as abdomen, 3rd thoracic segment with dorsal hump | <i>C. longicaudis</i> . |
| b. Furca less than half as long as abdomen, 3rd thoracic segment without dorsal hump | <i>C. concinna</i> . |

CORYCELLA GIBBULA Giesbr.

Corycæus gibbulus Giesbrecht (10).

Corycæus pellucidus Wolfenden (11).

? *Corycæus megalops* Will.-Suhm (1).

Common in all the gatherings, upwards of 120 specimens.

The most easily recognised characters of the female of this

species are the deep cephalon with eyes rather small and set far apart, the abdomen widest at its posterior third (without furca) and usually bearing two spermatophores, the furca contained $2\frac{1}{4}$ times in the rest of the abdomen, the middle furcal seta thick and equal in length to the width of the furca, and the setose pad on the antero-ventral part of the abdomen.

Wolfenden (11. p. 1027) has described at some length a female *Corycaeus* which occurred plentifully in the Maldive collections, and which is apparently identical with the above. He ascribes it to *C. pellucidus* Dana, and records *C. gibbulus* as a separate species. He remarks, however, that he believes that the *C. pellucidus* of the Maldive collections is probably identical with *C. gibbulus*. His figure of the fourth foot (fig. 9, pl. xcix.) is evidently incorrect in showing an endopodite bearing a long seta, as in the text it is said that no endopodite is present.

Giesbrecht's (10) figure of the female abdomen of *C. gibbulus* in lateral view is not so deep nor so irregular in outline as are all my specimens; in this they agree more nearly with Wolfenden's figure, but I think there can be no doubt that all these forms are identical.

It seems not improbable that Willemoes-Suhm's *C. megalops* was in reality this species; but his description and figure, as given by Brady (1), can hardly be regarded as constituting a valid diagnosis. Brady's *C. pellucidus* may also include it with others.

Distribution. Red Sea, Arabian Sea, Indian Ocean (many records), and Tropical Pacific.

CORYCELLA BREVIS, sp. n. (Pl. X. figs. 1-6, Pl. XI. fig. 7.)

Female (Pl. X. figs. 1, 2).—Length .85 mm.; cephalothorax, in middle line, .54 mm.; abdomen and furca .3 mm.; cephalon rather deep, curved dorsally in lateral view; eyes large, prominent in dorsal view.

2nd thoracic segment with slight dorsal hump, as in *C. gibbula* and *C. longicaudis*.

3rd thoracic segment (Pl. X. fig. 6) with comparatively short lateral points.

Abdomen widest at its posterior $\frac{2}{5}$ excluding furca; in lateral view the abdomen is parallel-sided for about $\frac{3}{5}$ of its length, and is then tapered to the furca; it has a slightly spinulose antero-ventral boss.

Furca about 6×1 , contained $2\frac{1}{3}$ times in rest of abdomen; its median terminal spine not very strong, about twice as long as width of furca.

1st and 2nd antennæ (Pl. XI. fig. 7) as in *C. gibbula*.

1st to 3rd feet (Pl. X. figs. 3, 4) almost the same as in *C. gibbula*. The 3rd joints of the exopodites of the 1st and 2nd feet are finely serrate, in the 3rd foot the serrations are not visible.

4th foot (Pl. X. fig. 5) as in *C. gibbula*, hollowed on distal margin of 2nd basal; inner margin of the 2nd basal forms an acute angle with its base.

The characters which distinguish this species from *C. gibbula* are the proportionately greater length and different form of the abdomen and the shorter 3rd thoracic spines.

Only one specimen was found.

CORYCELLA CONCINNA Dana.

In five gatherings, about 30 specimens.

Giesbrecht (10) has given a figure of the female of this species by which it can easily be recognised, but he does not refer to the presence of a setose pad, as in *C. gibbula*, on the antero-ventral part of the abdomen.

Distribution. Widely distributed in the Indian Ocean, Tropical and South Pacific.

CORYCELLA CARINATA Giesbr. (Pl. XI. fig. 10.)

In five gatherings, 55 specimens.

Length of females .85 mm.

The characteristic features of this species are the cephalon (deep from front to back), the small eyes moderately far apart, the long slender thoracic spines, and the abdomen, widest at its anterior fourth (excluding furca), with a ventral setose pad. The furca is about half as long as the rest of the abdomen.

CORYCELLA CURTA, sp. n. (Pl. X. figs. 7-11, Pl. XI. figs. 1-6.)

Female (Pl. XI. figs. 1, 2).—Length .7 mm. Very close in general appearance to *C. carinata*, but may be distinguished by the more slender build in lateral view, by the shorter thoracic spines, which do not reach as far as the genital openings, and by the absence of the patch of fine setæ or spinules on the antero-ventral part of the abdomen.

The furca is short, about 2×7 , and contained $2\frac{1}{2}$ times in the length of the rest of the abdomen (Pl. XI. fig. 3), which is broadest at its anterior fourth and tapered posteriorly.

The appendages have no special features. The fine serrulation, found on the third joints of the exopods in some species, is absent (Pl. X. figs. 7, 8). The 2nd basal of the fourth foot (Pl. X. fig. 11) is rounded on its inner face, and does not form one straight line with the inner face of the 1st basal. The angle between the base and inner margin of the 2nd basal is slightly obtuse.

Only one specimen was found.

In the same gathering there occurred two specimens which seem to be the males of the above, on account of the similarity of their thoracic spines, fourth feet and furca, and their small size.

Male (Pl. XI. figs. 4-6). Length .65 mm. Cephalothorax in middle line .4 mm., abdomen and furca .24 mm. The form of the abdomen (Pl. XI. fig. 4) is more easily shown in the figure than described. The outer edges of the 3rd joints of the exopodites of 1st and 3rd feet are not serrulate. The angle between the base and inner margin of the 2nd basal of the 4th foot (Pl. XI. fig. 5) is slightly obtuse.

CORYCELLA sp., ♂. (Pl. XI. figs. 8, 9.)

There were present numerous specimens of males of *Corycella* belonging to at least two species judging by size alone, as in other characters they seemed to be in agreement. These doubtless represent the males of *C. gibbula*, *C. concinna*, and *C. carinata*, but I have not been able to refer them to their respective females. In size the larger measured .85 mm. and the smaller .78-.8 mm. Dahl's (5) recognition of Dana's *C. gracilis* is based on a supposed identification of a figure of a male; but Dana's (9) figures would apply equally well to any one of these specimens, and I do not think that there are any grounds for regarding his description as valid.

The proportional length of abdomen and furca in these specimens was 7:3; in one of Dana's figures of *C. gracilis* it is 3:2 and in the other 4:2. Cleve (2) has given figures of the male of *C. gibbula*, which agree fairly well with my specimens, except that the width of the abdomen is greater in his figures. He states that the proportion of abdomen to furca is 2:1, but in one figure shows it as 9:5, and in the other as 8:3, so it is possible that he may have been dealing with more than one species.

The figures (Pl. XI. figs. 8, 9) are taken from a specimen of the larger form.

Genus *CORYCÆUS*.

Of the genus *Corycæus*, as restricted above, there is a considerable number of more or less well described forms, which may be conveniently summarised under the grouping adopted by Dahl.

Of the forms with a very long furca, a convenient but heterogeneous group, Giesbrecht has figured *C. longistylis* and *C. furcifer*, while *C. latus* of Dana is easily recognised from his figure.

The species of which the females have a one-jointed abdomen are, according to Giesbrecht, *C. alatus*, *C. flaccus*, and *C. elongatus*; to them Dahl adds *C. limbatus* of Brady, originally described from a male.

Corycæus robustus stands alone in having the end claw of the 2nd antenna elongated in both sexes.

Of the forms without setæ on the genital segment of the female, all of comparatively large size, Giesbrecht has dealt with *C. speciosus*, *C. danæ*, and *C. ovalis*, while Dahl accepts as a valid description the *C. vitreus* of Dana.

The remaining species, which do not fall into any of the above groups, are mostly of very small size. They all have setæ at the genital pores of the female abdomen, and may be divided into two groups according as the endopodite of the fourth foot bears one or two setæ. Of the first group *C. obtusus*, *C. gracilicaudatus*, and *C. venustus* have been figured by Giesbrecht; *C. minutus*, *C. catus*, and *C. pacificus* have been described, in his synoptic table, without figures, by Dahl, who also admits *C. latus* of Dana

and *C. huxleyi* of Lubbock. Of the second group, with two setæ on the endopodite of the fourth foot, *C. lubbocki* and *C. tenuis* have been figured by Giesbrecht; *C. anglicus* is a well-known species in British waters; *C. amazonicus*, *C. asiaticus*, *C. minimus*, and *C. africanus* figure as new species in Dahl's table; and *C. erythræus* has been described and figured by Cleve (4).

The three new species described below belong to the last group.

CORYCÆUS LONGISTYLIS Dana.

C. longistylis Dana (9).

C. varius Brady (1).

C. longistylis Giesbrecht (10).

Present in four gatherings, 5 females and 7 males.

Both sexes of *C. longistylis* are easily distinguished from *C. lautus* and *C. furcifer*, which also have a long furca, by the broad spreading 3rd thoracic segments. The female is not completely figured by Giesbrecht, but Brady's figure of the whole animal (1) (pl. lii. fig. 1), under the name *C. varius*, is fairly accurate.

Distribution. Indian Ocean, China Sea, and Tropical Pacific.

CORYCÆUS LAUTUS Dana.

C. lautus Dana (6).

C. lautus Dahl (5).

Present in four gatherings, 12 females and 29 males.

The female is distinguishable from that of *C. furcifer* by its larger size, 2.75 mm., *C. furcifer* ♀ measuring only 1.8 mm., and by the form of the abdomen, the anal segment being much wider in front than behind, while in *C. furcifer* it is only slightly tapered. The male of *C. lautus* (2.15 mm.) is considerably larger than that of *C. furcifer* (1.3–1.45 mm.), but otherwise resembles it rather closely in general appearance. The furca, however, is only $1\frac{1}{5}$ times as long as the rest of the abdomen, instead of almost $1\frac{1}{2}$ times as in *C. furcifer* ♂.

Both species can be readily distinguished by dissection, *C. lautus* having two setæ on the endopodite of the fourth foot, while in *C. furcifer* there is only one. Dana's (9) figure of *C. lautus* ♀ is easily recognisable as distinct from *C. furcifer*.

Distribution. Kingsmill I. (Dana), N.E. Atlantic.

CORYCÆUS ALATUS Giesbrecht.

The female of *C. alatus* is well represented in the collection, 36 specimens occurring in five gatherings. The shape of the abdomen, as well figured by Giesbrecht, makes it unmistakable. The males of this species and *C. flaccus* present some difficulties. While the females of *C. alatus* and *C. flaccus* number respectively 36 and 12, there are 76 specimens of a male which corresponds closely to Giesbrecht's (10) description of *C. elongatus* ♂. These specimens are undoubtedly the males of *C. alatus* and *C. flaccus*,

but I have been unable to distinguish between them or to separate them satisfactorily from *C. elongatus* ♂. They can be readily picked out under a dissecting microscope, owing to the fact that, apart from differences of form, the maxillipedes are coloured a rusty-red.

Distribution. Tropical Pacific.

CORYCEUS FLACCUS Giesbrecht.

There is nothing to add to Giesbrecht's (10) figures and description of this species, which is easily separated from *C. alatus*, the only species which it at all resembles, by the form of the abdomen and furca. There occurred twelve specimens, females, in three gatherings.

The other two species of this group, *C. elongatus* and *C. limbatus*, which Dahl (5) regards as distinct, were not found in the collection.

Distribution. Mediterranean, Indian Ocean, Tropical Pacific.

CORYCEUS ROBUSTUS Giesbrecht.

C. venustus Brady (1).

C. robustus Giesbrecht (10).

Present in three gatherings, 10 males and 2 females.

The female is recognisable by its very large size and by the form of the genital segment, which is provided with lateral ridges and overlaps the anal segment in dorsal view.

There can be no doubt that the species which Brady (1) recorded as *C. venustus* Dana was in reality *C. robustus*. The detailed figure of the abdomen shows the genital segment overlapping the anal, in a way which is characteristic of that species alone. The figure (pl. liv. fig. 8) of the whole animal is somewhat misleading, as the artist or engraver evidently, after the picture was finished, mistook the lateral abdominal ridges for egg-sacs, and touched them up with a view to increasing the resemblance. Anyone who compares Giesbrecht's figure of *C. robustus* ♀ (11) (pl. li. fig. 38) with Brady's figure of *C. venustus* (1) (pl. liv. fig. 8) can hardly avoid the conclusion that both had the same species before them. The dimensions given by each are identical. Brady's description does not mention any characters of specific value. Giesbrecht's suggestion that Brady's *C. venustus* was really *C. obtusus* seems to me to be quite baseless.

Distribution. Red Sea, Arabian Sea, Indian Ocean, Tropical Pacific, and off Cape of Good Hope.

CORYCEUS SPECIOSUS Dana.

An easily recognised species, well represented in the collection.

It occurred in six gatherings, 22 females and 33 males.

Distribution. Mediterranean, Red Sea, Arabian Sea, Indian Ocean, Tropical Pacific, off Cape of Good Hope, Tropical and North Atlantic.

CORYCÆUS DANÆ Giesbrecht.

Dahl (5) has proposed that Giesbrecht's name of *C. danæ* should give way to Dana's *C. crassiusculus* which he believes to represent the male of the same species. There is some resemblance in the figure given by Dana to *C. danæ* ♂, but there does not seem to be any reason for upsetting a well-established name with a recognisable description on account of its possible identity with a very imperfect description with insufficient figures, to which, at best, it can only be brought home by a process of exclusion.

C. danæ occurred in seven gatherings, 44 females and 70 males.

Distribution. Mediterranean Sea, Red Sea, Arabian Sea, Indian Ocean, Tropical Pacific, off Cape of Good Hope.

CORYCÆUS GRACILICAUDATUS Giesbrecht. (Pl. XI. figs. 11, 12.)

Dahl (5) has proposed that Giesbrecht's name should be regarded as a synonym of Dana's *C. agilis*, which represents a male, length $\frac{1}{30}$ inch or .83 mm. Females, which are almost certainly Giesbrecht's *C. gracilicaudatus*, occurred in five gatherings, nine specimens. In Dahl's key they fall in with *C. agilis*.

What I believe to be the male of the species occurred in three gatherings, 50 specimens (Pl. XI. figs. 11, 12). The length was .76 mm. The proportions of the abdomen and furca agreed fairly well with Dana's figure of *C. agilis*, but the 3rd thoracic segment had the distance between its points less than the width of the hinder end of the 2nd thoracic segment. In Dana's figure the points are spread widely outwards. These males were remarkable in having the longest furcal seta bright red.

Distribution. Red Sea, Arabian Sea, Indian Ocean, Tropical Pacific.

CORYCÆUS CATUS Dahl. (Pl. XII. figs. 1-3.)

Dahl (5) has given the above name to a species of *Corycæus*, the female of which is only to be distinguished, according to his diagnostic table, from *C. obtusus* (*C. ovalis* of Dahl) by having outstanding sharp points on the ends of the 4th thoracic segment, whereas in *C. obtusus* the ends of that segment are short and blunt. The other characters, extracted from his table, are—Endopodite of 4th foot with one seta; abdomen with seta behind the genital opening; size not more than 1 mm.; furca comparatively short; third thoracic segment spreading, more than $\frac{3}{4}$ as broad as first, the points not reaching to the distal end of the genital segment; anal segment very little longer than its basal width.

There are several specimens of a female *Corycæus* in the collection which agree with the above diagnosis and are either *C. catus* or a new species, the probability being in favour of the former view. They occur in five gatherings, 90 specimens in all. The 3rd thoracic segment in dorsal view, though spreading,

is not so wide as in *C. obtusus*, being at its widest part, a little behind the anterior margin, only just $\frac{3}{4}$ as wide as the widest part of the cephalon (Pl. XII. fig. 1). The points of the segment are slightly contracted, the distance between them being only $\frac{2}{3}$ of the width of the cephalon. The total length is .9 mm.

The most noticeable features, in comparison with *C. obtusus*, are the sharp slender points to both the 3rd and 4th thoracic segments (Pl. XII. fig. 2), and the somewhat larger eyes, separated by rather less than their own diameter. The form of the abdomen and furca is very similar in both species.

CORYCÆUS OBTUSUS Dana. (Pl. XII. figs. 4-6.)

Corycæus obtusus Dana.

C. obtusus Giesbrecht.

C. ovalis Dahl.

According to Dahl (5), Giesbrecht is in error in his identification of the species which he has described and figured under the name of *C. obtusus* Dana, Dana's species being different and not found subsequently. He believes that Giesbrecht's description really refers to the species which Claus (2) had described under the name of *C. ovalis*.

Under these circumstances the course least liable to cause confusion would be to reject both Dana's and Claus's names; however, for the present, I assume that Giesbrecht's name is correct. Eighteen specimens, females, of the species in question occurred in the collection, in three gatherings.

The distinguishing characters are the size, 1.05-1.1 mm., the wide spreading third thoracic segments, the blunt tips to the fourth thoracic segments (Pl. XII. fig. 5), the fine setæ in front of the genital openings, the anal segment as long as it is broad at the base and nearly as long as the furca, and the single seta on the endopodite of the fourth foot (Pl. XII. fig. 4).

Distribution. Red Sea, Arabian Sea, Indian Ocean, Tropical Pacific, Tropical Atlantic.

CORYCÆUS TENUIS Giesbrecht. (Pl. XII. figs. 8, 9.)

Of the forms with two setæ on the endopodite of the fourth foot and a moderately long furca there are two species, females, in the collection. One of these is described below as new, the other appears to be *C. tenuis*. In Dahl's (5) key the choice lies between *C. anglicus* and *C. tenuis*, the former being distinguished in the key by the presence of a corner on the inner side of the lateral prolongation of the 3rd thoracic segment and by a small hook-like ventral process on the proximal end of the abdomen. Both these characters are present in my specimens and, if the table were closely followed, they ought to be *C. anglicus*. They are, however, not that species, being distinguished from it by the shorter genital segment with much more slender setæ, the form of the anal segment, which is parallel-sided and about twice as long

as wide, and the furca, which is slightly longer and more slender. They agree well, on the other hand, as far as the text and figures go, with Giesbrecht's description of *C. tenuis*, though that writer makes no mention of the ventral hook on the genital segment.

The length, 1.05 mm., is slightly greater than that given by Giesbrecht, viz. .9 mm. The length of the cephalothorax in the middle line, dorsal view, is .64 mm., of the abdomen and furca .41 mm., the proportional lengths of abdominal segments and furca being 14 : 8 : 18. Measured along the ventral margin the proportions are more nearly 12 : 10 : 17. The pigment of the eye-apparatus shows very distinctly through the body as of a blue-green colour.

The second antenna (Pl. XII. fig. 9) bears a long spine on the first basal joint and a much shorter spine, one-third as long, on the second basal joint. The inner margin of the second basal ends distally in two strong teeth. The terminal claw of the second antenna is just equal to the spine of the second basal.

The swimming-feet have no distinctive features, except that the terminal spine of the exopodite of the second foot is very slightly curved.

Six specimens were found in two gatherings.

Distribution. Indian Ocean and Tropical Pacific.

CORYCÆUS DUBIUS, sp. n. (Pl. XII. fig. 7, Pl. XIV. figs. 5-9.)

In the Maldive collections Dr. Wolfenden (11) obtained a specimen of *Corycæus*, which, following Dahl's table, ought to be *C. amazonicus*, but, as he remarks, without figures it is impossible to refer it with certainty to that species. In the Christmas Island collection there occurred one specimen of a female, described below under the name of *C. dubius*, which may well be the same species as that to which Dr. Wolfenden refers, but again the absence of figures precludes certainty. The particulars given by Dr. Wolfenden—namely, the size, 1.0 mm., and the proportionate lengths of abdomen and furca 7 : 8 : 9—come very near .97 mm. and 21 : 23 : 28, the corresponding measurements in my specimen. The lateral prolongations of the third and fourth thoracic segments are short in both specimens. In Wolfenden's specimen, however, the spine on the second joint of the second antenna is said to be "not more than half the length of that of the 1st basal, and shorter than the distal hook," but in mine the spine in question is just one-third as long as that on the 1st basal and is distinctly longer than the distal hook.

Cleve (4) has described a species, *C. erythreus* ♀, from the Red Sea, which is very closely allied to both the above-mentioned forms, but if his description be taken as accurate it must be distinct. The female genital segment has setæ on the genital openings and a ventral hook, the endopodite of the 4th foot has two setæ, and the furca is moderately long. The size .88-.94 mm. is slightly less than that of *C. dubius*. The proportions of the

abdominal segments and furca are 10:10:12, *i. e.* the genital and anal segments are equal; in the figure, however, the genital segment is shown as being the longer. The most noticeable difference is in the 2nd antenna, in which the spine of the 2nd basal is figured as being half as long as that of the 1st basal, and is said to reach to the distal margin of the joint. In my species the spine of the 2nd basal is only one-third as long as that of the 1st, and falls short of the distal margin of the joint by half its own length.

In view of this uncertainty it seems advisable to give the Christmas Island specimen a distinct name until the specific characters of *C. amazonicus* and *C. erythræus* are more fully known.

Female (Pl. XIV. fig. 5).—Length .97 mm.; cephalothorax in mid-dorsal line .58 mm.; abdomen .39 mm. (Pl. XIV. fig. 6); proportions of abdominal segments and furca, dorsally 21:23:28, ventrally 16:22:27. Sides of cephalon parallel, Ceph. + Th. 1 being about twice as long as broad. Points of 3rd thoracic segment (Pl. XIV. fig. 7) not very long (broken in my specimen), with thickened margin on posterior edge. 4th thoracic segment short, with sharp points. Genital segment about $1\frac{1}{3}$ times as long as wide, with setæ on genital openings, in lateral view with a small sharp hook anteriorly on ventral edge. Anal segment a little longer than genital segment and slightly overlapped by it dorsally, about three times as long as wide. Furca slightly diverging, a little longer than anal segment. Furcal rami about 1×10 , terminal setæ missing.

1st antenna six-jointed, proportional lengths of joints $\frac{1\ 2\ 3\ 4\ 5\ 6}{3\ 3\ 4\ 4\ 2\ 2}$.

2nd antenna (Pl. XIV. fig. 8) with spine on 1st basal very long; spine on 2nd basal short, about $\frac{1}{3}$ as long as that on 1st basal and falling short of the nearest point of distal margin of joint by about half its own length. Distal margin of 2nd basal with two sharp teeth. Terminal spine of 2nd antenna very strong, shorter than spine on 2nd basal.

Mouth-parts not satisfactorily made out.

Jointing and number of setæ of swimming-feet normal.

1st foot: exopodite with broad terminal spine, almost as long as endopodite, with fine denticulations.

2nd foot (Pl. XIV. fig. 9): terminal spine of exopodite almost straight, with moderately coarse denticulations on outer edge and two small distal serrations on inner edge (possibly an individual character and not specific).

3rd foot with long slender terminal spine on exopodite, the proportional lengths of joints and spine being 28:20:60:70.

4th foot (Pl. XII. fig. 7): endopodite small, with two setæ; exopodite slender, the proportional lengths of its joints being approximately 6:4:5; outer edge seta on 1st joint almost as long as 2nd joint, blunt process on 2nd basal joint internal to endopodite.

CORYCÆUS ANDREWSI, sp. n. (Pl. XIII. figs. 7-9, Pl. XIV. figs. 1-4.)

Female (Pl. XIV. fig. 1).—Length .95 mm.; cephalothorax in middle line .64 mm., to end of thoracic spines .7 mm.; abdomen .31 mm. (Pl. XIV. fig. 4). Proportional lengths of abdominal segments and furca 19:12:10. Furcal rami about five times as long as wide. The genital segment is about $\frac{2}{3}$ as wide as long and $\frac{4}{5}$ as deep, in lateral view, as long; the antero-ventral angle is very marked in lateral view, being almost a right angle, rounded off at the apex and furnished with a small patch of minute spinules. The points of the 2nd thoracic segment are short and notched on the inner margin. The points of the 4th thoracic segment are very short, but sharp at the extreme tip.

The eyes are of medium size and are separated by rather less than their own diameter.

1st antenna, proportional lengths of joints $\frac{1\ 2\ 3\ 4\ 5\ 6}{4\ 3\ 4\ 5\ 3\ 2}$.

2nd antenna (Pl. XIII. fig. 9): 1st basal with long spine; 2nd basal with spine about $\frac{2}{3}$ as long as that on the first, and two rather slender teeth on its distal edge. The terminal spine of the 2nd antenna is about half as long as that on the 2nd basal.

The proportional lengths of the joints of the swimming-feet are best seen in the figures.

The outer edge spines of the exopodites of the 1st and 2nd feet (Pl. XIII. fig. 8, Pl. XIV. fig. 3) have well-developed laminae, but on the 3rd foot they are very slightly laminate. The terminal spine on the exopodite of the 2nd foot is slightly curved, on the 1st and 3rd feet it is straight. In the 4th foot (Pl. XIII. fig. 7) the outer edge spine of the 1st joint of the exopodite is short and slender. The endopodite of the 4th foot bears two moderately large setae.

Five specimens, females, were found in two gatherings.

Comparing *C. andrewsi* with the other species in which there are two setae on the endopodite of the 4th foot, we find that it is separated from *C. lautus*, *C. lubbocki*, *C. tenuis*, *C. erythræus*, *C. venustus*, *C. anglicus*, and *C. africanus* by its short furca, which is less than $\frac{1}{3}$ of the length of the rest of the abdomen. In *C. amazonicus* the anal segment is said to be longer below than the genital, a fact which at once distinguishes that species. In *C. asiaticus* and *C. minimus*, according to Dahl's table, the furca agrees in being about half as long as the genital segment, but the genital segment is said to be respectively two and three times as long as the anal, while in *C. andrewsi* it is only $1\frac{1}{2}$ times as long.

CORYCÆUS MURRAYI, sp. n. (Pl. XIII. figs. 1-6.)

Female (Pl. XIII. figs. 1, 2).—Length 1.2 mm.; cephalothorax in middle line .75 mm.; abdomen and furca .43 mm. The proportional lengths of the abdominal segments and furca in .01 mm. are 18:13:12. The wings of the 3rd thoracic segment

(Pl. XIII. fig. 3) are long, sharp-pointed, and spreading, the width between the points being $\frac{7}{8}$ of the width of the cephalon and equal to the length of the abdomen without furca. The abdomen is wide in front and regularly tapered to the furca, the segmentation between the genital and anal segments being rather obscure. Immediately behind and exterior to each genital opening is a small blunt process or papilla projecting beyond the margin of the genital segment in dorsal view. The setæ at the genital openings are very small and might easily be overlooked.

The 2nd antenna (Pl. XIII. fig. 4) is much stouter than in *C. andrewsi* and has one strong tooth on the inner margin of the 2nd joint. The seta on the 2nd joint is rather more than half as long as that on the 1st joint, and reaches almost to the end of the inner edge tooth. The terminal claw of the 2nd antenna is strong.

The swimming-feet have no special characters. The terminal spine of the exopodite of the 2nd foot (Pl. XIII. fig. 6) is only very slightly curved. The endopodite of the 4th foot (Pl. XIII. fig. 5) bears two moderately strong setæ, and the outer edge spine of the 1st joint of the exopodite is rather short.

This species is rather closely allied to the above-described *C. andrewsi*, having, like it, setæ on the female genital segment, two setæ on the endopodite of the fourth foot, and a short furca.

Six specimens were found in three gatherings.

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EXPLANATION OF THE PLATES.

All the figures have been drawn with the aid of a camera lucida.

PLATE X.

- Fig. 1. *Corycella brevis* ♀, dorsal view.
 2. " " ♀, lateral view.
 3. " " ♀, 3rd foot.
 4. " " ♀, 1st foot.
 5. " " ♀, 4th foot.
 6. " " ♀, 3rd thoracic segment, mounted.
 7. *Corycella curta* ♀, 3rd foot, exopodite.
 8. " " ♀, 2nd foot.
 9. " " ♀, 3rd thoracic segment, mounted.
 10. " " ♀, 2nd antenna.
 11. " " ♀, 4th foot.

PLATE XI.

- Fig. 1. *Corycella curta* ♀, dorsal view.
 2. " " ♀, lateral view.
 3. " " ♀, abdomen, dorsal view.
 4. " " ♂, abdomen, dorsal view.
 5. " " ♂, 4th foot.
 6. " " ♂, 3rd thoracic segment, mounted.
 7. *Corycella brevis* ♀, 2nd antenna.
 8. *Corycella* sp., ♂, dorsal view.
 9. " " ♂, 4th foot.
 10. *Corycella carinata* ♀, abdomen, lateral view.
 11. *Corycæus gracilicaudatus* ♂, dorsal view.
 12. " " ♂, lateral view.

PLATE XII.

- Fig. 1. *Corycæus catus* ♀, dorsal view.
 2. " " ♀, 3rd and 4th thoracic segments, mounted.
 3. " " ♀, 4th foot.
 4. *Corycæus obtusus* ♀, 4th foot.
 5. " " ♀, 3rd and 4th thoracic segments, mounted.
 6. " " ♀, 2nd antenna.
 7. *Corycæus dubius* ♀, 4th foot.
 8. *Corycæus tenuis* ♀, 3rd and 4th thoracic segments, mounted.
 9. " " ♀, 2nd antenna.

PLATE XIII.

- Fig. 1. *Corycæus murrayi* ♀, dorsal view.
 2. " " ♀, lateral view.
 3. " " ♀, 3rd and 4th thoracic segments, mounted.
 4. " " ♀, 2nd antenna.
 5. " " ♀, 4th foot.
 6. " " ♀, 2nd foot.
 7. *Corycæus andrewsi* ♀, 4th foot.
 8. " " ♀, 2nd foot.
 9. " " ♀, 2nd antenna.

PLATE XIV.

- Fig. 1. *Corycæus andrewsi* ♀, dorsal view.
 2. " " ♀, 3rd and 4th thoracic segments, mounted.
 3. " " ♀, 1st foot.
 4. " " ♀, abdomen, dorsal view.
 5. *Corycæus dubius* ♀, dorsal view.
 6. " " ♀, abdomen, lateral view.
 7. " " ♀, 3rd and 4th thoracic segments, mounted.
 8. " " ♀, 2nd antenna.
 9. " " ♀, 2nd foot, exopodite.

14. On some New Zealand Spiders.

By H. R. HOGG, M.A., F.Z.S.

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(Text-figures 92-96.)

Prof. Chas. Chilton, of Christchurch, New Zealand, suggested to his students that they should in the vacation collect specimens at various points over the North and South Islands, wherever their homes were situated. The result is that from some half-dozen localities specimens of spiders were brought in within the space of a few weeks, and these he has kindly sent to me.

New Zealand for a considerable period has been rather well worked from a zoological point of view, and its spider fauna described not only by Dr. Koch but by local men such as Messrs. Urquhart and Goyen. It is therefore not a little remarkable to find in the small collection here described so large a proportion of new species, and, moreover, the same new species, in one case from three, and another from two widely separated localities at the same time. The thirty specimens comprise no less than twelve species of eleven genera. Of the species, four are new, and one a local variety of an Australian species not hitherto recorded from New Zealand. They were collected mostly from Ruakura and Wellington, in the North Island, by Miss B. D. Cross, and one by Mr. E. P. Turner from the summit of Mt. Ngauruhoe shortly after an eruption. The latter appears to have minute particles of volcanic dust adhering to it.

The species from the South Island were taken by Messrs. R. N. Hawkes and G. M. Thomson, and by Prof. Chilton himself.

On Mt. Peel, in the Province of Canterbury, Mr. Hawkes picked up at random a male *Uliodon* of a new species, a new species of *Argoctenus*, a male of *Cambridgea antipodiana* (with its unique form of stridulatory organ), and three females of *Porrothele antipodiana* Walck., a new locality for the two latter species.

In 1905 (Zool. Jahrb. xxi. pt. 4, 1905) M. Simon formed a genus *Mynoglenes* for a spider (*M. insolens*) from the Chatham Islands, 500 miles east of New Zealand, and I was recently able to describe another species (Reports Phil. Inst. of Canterbury, N. Z., 1909, vol. i. p. 165) from the Sub-Antarctic Auckland and Campbell Islands, south of New Zealand, but the genus had not so far been recorded from New Zealand itself. Miss Cross, Prof. Chilton, and Mr. Turner send specimens, one each from separate localities—Ruakura and Mt. Ngauruhoe in the North, and Picton in the South Island. These, although differing in size, are all adult and appear to be similar. I have taken them to be the same species.

Hemiclæa rogenhoferi L. Koch and *Araneus verrucosus* Walck., from Ruakura, are among the few spiders hitherto known to be common to both New Zealand and Australia; and *Tetragnatha*

ferox L. Koch, with some slight variations, is now for the first time recorded from New Zealand.

Prof. Chilton sends *Desis marina* Camb., taken by himself in Lyttelton Harbour, and a *Pardosa* from Picton Harbour.

Suborder **MYGALOMORPHÆ.**

Family **AVICULARIDÆ.**

Subfamily **DIPLURINÆ.**

Group **MACROTHELEÆ.**

Genus **PORRHOTHELE** Simon.

PORRHOTHELE ANTIPODIANA Walck.

Three females from Mt. Peel, Canterbury. Collected by Mr. R. N. Hawkes.

Suborder **ARANEÆ VERÆ.** Section **ECRIBELLATÆ.**

Family **DRASSIDÆ.**

Subfamily **HEMICLÆINÆ.**

Genus **HEMICLÆA** Thor.

HEMICLÆA ROGENHOFFERI L. Koch,

One male from Ruakura. Miss B. D. Cross.

Family **ARGIOPIDÆ.**

Subfamily **ARGIOPINÆ.**

Group **TETRAGNATHÆÆ.**

Genus **TETRAGNATHA** Latr.

TETRAGNATHA FEROX L. Koch, var. **CROSSÆ**, nov.

One male and two females from Ruakura. Miss B. D. Cross.

A few variations from the Australian form are noted below, but it is so like in other respects that I do not think it can be specifically separated therefrom.

Group **ARANEÆ.**

Genus **META** Clerck.

META ARGENTATA Urquhart.

Nephila argentatum Urq. Trans. N.Z. Inst. vol. xix, p. 92.

One male and two females from Ruakura. Miss B. D. Cross.

These correspond so nearly in all respects with Mr. Urquhart's description of the *Nephila* above mentioned, except that the side eyes

are close together, that I have no doubt as to their belonging to the same species. The silvery colouring of the abdomen is suggestive of some of the *Nephila*, especially *N. venosa* L. Koch, but the shape of its cephalothorax and shorter lengths of tarsal joints show that it is not a *Nephila*, of which genus no species have been recorded from New Zealand.

Genus ARANEUS Linn.

ARANEUS VERRUCOSUS Walck.

Two males and six females from Ruakura. Miss B. D. Cross.

Family CLUBIONIDÆ

Subfamily CTENINÆ.

Group CTENEÆ.

Genus ULIODON L. Koch.

ULIODON HAWKESI, sp. n.

One male and one female from Mt. Peel, Canterbury.
Mr. R. N. Hawkes.

One male from Wellington. Miss B. D. Cross.

Subfamily LIOCRANINÆ.

Group MITURGEÆ.

Genus ARGOC TENUS L. Koch.

ARGOC TENUS AUREUS, sp. n.

One female from Mt. Peel. Mr. R. N. Hawkes.

Family AGALENIDÆ.

Subfamily CYBÆINÆ.

Group DESIÆ.

Genus DESIS Walck.

DESI S MARINA Cambr.

One female from Lyttelton Harbour. Prof. Chilton.

Group CYBÆEÆ.

Genus MYNOGLENES Simon.

MYNOGLENES CHILTONI, sp. n.

One male from Ruakura. Miss B. D. Cross.

One male from Mt. Ngauruhoe, Waikato, N. Island. Mr. E. P. Turner. Shortly after an eruption.

One female from Picton, S. Island. Prof. Chilton.

Group *ARGYRONETÆ*.

Genus CAMBRIDGEA.

CAMBRIDGEA ANTIPODIANA White.

One female from Mt. Peel, Mr. R. N. Hawkes.

Family PISAURIDÆ.

Group *DOLOMEDEÆ*.

Genus DOLOMEDES Latr.

DOLOMEDES TRIDENTATUS, sp. n.

One female from Dunedin, Mr. G. M. Thomson.

Family LYCOSIDÆ.

Group *PARDOSEÆ*.

Genus PARDOSA C. Koch.

(Probably) *P. CANESCENS* Goyen.*Lycosa canescens* Goyen, Trans. N.Z. Inst. vol. xix. p. 203.

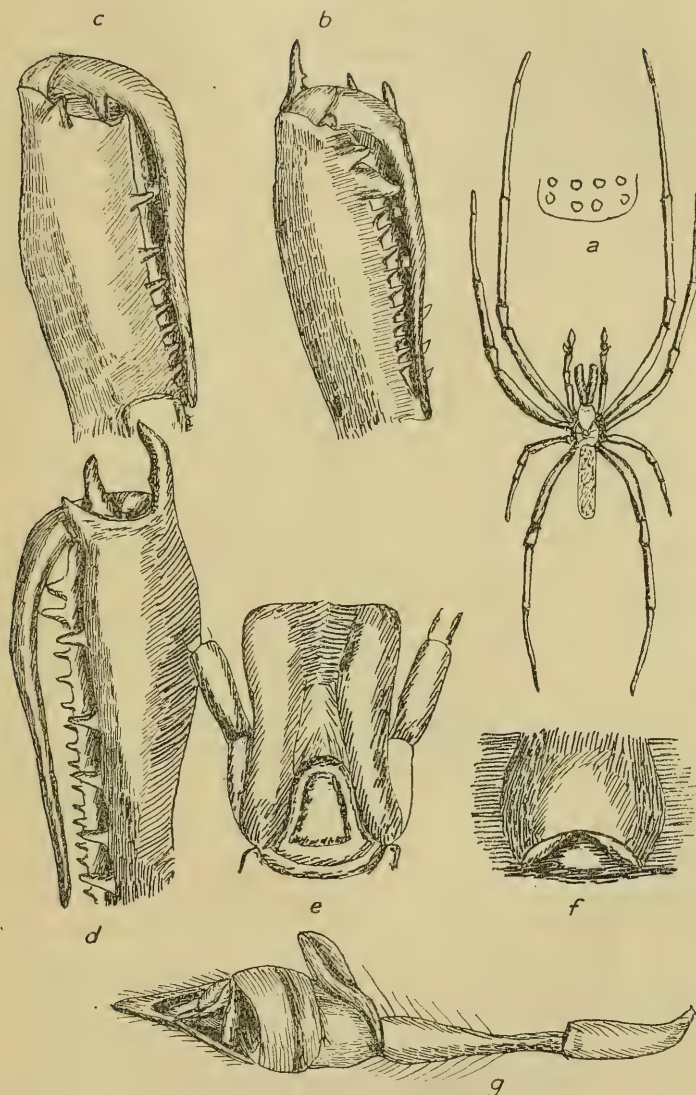
The specimens, one male and one female, agree closely with Mr. Goyen's description of his species, which he states he always found on river banks. Prof. Chilton collected this from a mud-bank in Picton Harbour, and I have little doubt as to its being the same. Its short broad lip, square front, two large equal teeth and one smaller on the inner margin of the falx-sheath, and procurved front row of eyes, show clearly that it belongs to C. Koch's genus *Pardosa*, and this would follow from Mr. Goyen's description of the lip alone.

TETRAGNATHA FEROX L. Koch, var. *CROSSÆ*, nov. (Text-fig. 92.)

Female, Cephalothorax, mandibles, maxillæ, coxæ, and legs orange-yellow. The lip, except on the front edge, is yellow-brown and the sternum somewhat darker. The scanty hairing is rather pale brown, and the spines on the legs dark brown. The cephalic part of the cephalothorax is bordered with a somewhat browner line, but with white hairs thereon, and there are two pairs of rather darker spots on the front of the rear slope. The abdomen above is yellow-grey, bordered with a dark grey wavy line on each side, the whole distance from front to rear. There are short white hairs rather thicker on the side slopes than on the back. Underneath it is a dingy yellow-grey with short brown hairs; there is a rather darker area running from the spinnerets to the breathing-apertures and epigyne.

The *cephalothorax* is a long oval, not quite twice as long as broad, rounded at the sides, the cephalic part distinctly raised above the thoracic. Between the end of the former and the rear slope

Text-fig. 92.



Tetragnatha ferox, var. *crossæ*. Male.

- a*, eyes; *b*, mandible of male from inside.
c, " female from inside.
d, " male from outside.
e, lip and maxillæ; *f*, epigyne; *g*, male palp.

are two pairs of depressions, one behind the other, divided by a rather broad ridge.

Viewed from above both rows of *eyes* are recurved, those of the rear row equal and equidistant two and a half times their diameter apart. The front median eyes are nearer together than the rear, and apparently rather larger; they are situated on the sides of a protuberance, and are as far from the rear eyes as from one another. The respective pairs of side eyes are a similar distance apart. As they are all dark and on black rims, the real size of the eye is difficult to distinguish. The *clypeus* is as broad as a front median eye.

The *mandibles* are as long as the cephalothorax, divergent, and protrude at an angle of 45 degrees. They have long upstanding hairs on the inner side and shorter ones on the outer edge. On the outer margin of the falx-sheath there are five rather long teeth, the upper one on the top edge being the largest. On the inner margin there is one large tooth at the top, one at the corner, then one small one a little way down, and then seven nearer together reaching to the top of the lip. On the inner side of the fang itself, near the base, is a short stout spine midway between the two marginal spines on the top edge of the sheath.

The *maxillæ* are long, broadest at the anterior end, where they rather bend back with a rounded corner at the outer edge; from here they slope in to about the middle and then out again. The trochanter of the palp is very long.

The *lip* is about two-fifths the height of the maxillæ, rounded in front with a rather prominent edge. It broadens out towards the posterior end, which is also rounded, and there is a depression all the way round a little distance from the margin.

The *sternum* is a long narrow shield-shape, twice as long as broad, hollowed in front, and with a prominent apophysis at each of the front corners; it is smooth and shiny, with a few fine upstanding hairs. There is a space between the second and third pair of coxæ, and the fourth pair are not quite contiguous to one another.

The *abdomen* is long and narrow, straight at the sides and slightly rounded at the front and rear.

The *epigyne* is a transverse oval, the inside filled with an oval convexity.

The *palpi* are thin. The tibial joint is twice as long as the patellar.

The *legs* are long and thin; the tibia of the front pair more than six times as long as the patella. There are four pairs of spines at the sides of tibiæ 3 and 4; the spines are fine and not very long.

The *male* is coloured the same as the female, except that the sternum is of the same bright yellow colour as the cephalothorax, maxillæ, and legs.

The mandibles are quite as long as the cephalothorax; on the inner margin of the falx-sheath are twelve teeth, the second of these being the largest. On the outer side there are three large

protuberances at the end, and five rather large teeth at intervals down the margin of the falcx-sheath.

The male differs from *T. ferox* L. Koch in the larger second tooth from top on the inside of the mandible, in the apophyses at the head, the two inner curving in the opposite direction to the outer, in the mandibles being quite as long as the cephalothorax, instead of shorter, in the tibial joint of the palp being distinctly longer than the patellar, and the palpal stigma being not more than half as long as in *T. ferox*, and the legs longer in proportion.

The measurements (in millimetres) are as follows:—

Male.

		Long.	Broad.			
Cephalothorax ...		3	2			
Abdomen		$5\frac{1}{2}$	1			
Mandibles		3				
		Trochanter Patella Metatarsus				
		Coxa.	& femur.		Patella & tibia.	Metatarsus.
Legs	1.	1	9	10	11	= 31
	2.	1	7	7	7	= 22
	3.	1	$3\frac{1}{2}$	$2\frac{1}{2}$	3	= 10
	4.	1	$6\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	= $20\frac{1}{2}$
Palpi		$\frac{1}{2}$	$2\frac{1}{2}$	2	$1\frac{1}{2}$	= $6\frac{1}{2}$

Female.

		Long.	Broad.			
Cephalothorax ...		3	$1\frac{3}{4}$			
Abdomen		7	2			
Mandibles		3				
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	1	7	8	9	= 25
	2.	1	6	6	6	= 19
	3.	1	$2\frac{1}{2}$	2	$2\frac{1}{2}$	= 8
	4.	1	5	5	$5\frac{1}{2}$	= $16\frac{1}{2}$
Palpi		$\frac{1}{2}$	$2\frac{1}{2}$	2	$1\frac{1}{2}$	= $6\frac{1}{2}$

T. ferox L. Koch, fairly common along the eastern and southern coasts of Australia, has not been previously recorded from New Zealand. The New Zealand and Australian females are practically identical, and I consider this to be a local variety, which I have named after Miss Cross, who sends a male and a female from Ruakura.

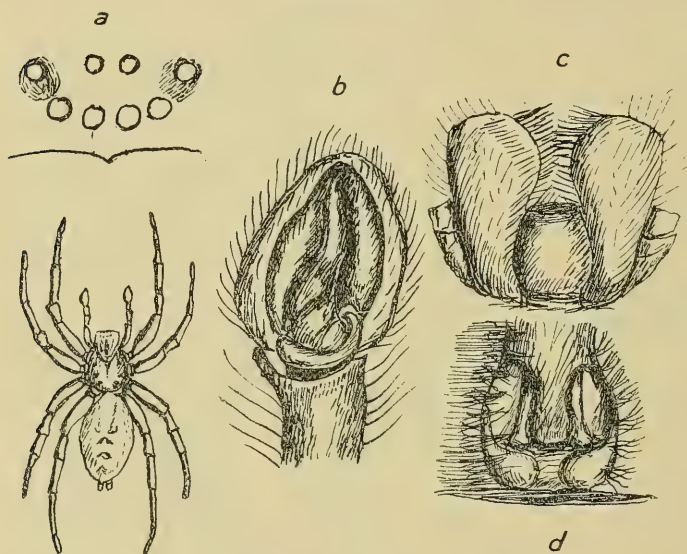
ULIODON HAWKESI, sp. n. (Text-fig. 93.)

Female. The cephalothorax is bright, rather pale yellow-brown, with short upstanding brown bristles and downlying white hairs. On the cephalic part there are three longitudinal darker lines—one median reaching from the eyes to the rear end, and one shorter each side, also a darker line round its margin. At the sides of the thoracic part is a darker brown marginal stripe.

Mandibles dark yellow-brown, with downlying white hairs and upstanding brown bristles; fangs bright red. Lip and maxillæ yellow-brown, with greyish-yellow hairs. Sternum yellow-brown, with whitish hairs. Coxæ pale yellow, with a dark band at the end. Femora yellow, with three dark bands underneath. The other joints of the legs dark yellow-brown, with black spines; grey scopulæ on all tarsi and metatarsi.

Abdomen above greyish-yellow mottled with black, sparsely covered with brown upstanding bristles and downlying white hairs. On the under side the fore part is yellow, with short yellow-brown hairs as far as the pulmonary apertures, the remainder pale yellowish grey. The sides are darker, nearly black, with longitudinal lines of yellow and white hairs.

Text-fig. 93.

*Utiodon hawkesi*. Female.

a, eyes; b, male palp; c, lip and maxillæ; d, epigyne.

The *cephalothorax* is convex, highest at the beginning of the rear slope, thence downwards to the eye-space. The cephalic part is rather more than half the greatest width of the thoracic, its sides rather straight, but those of the thoracic rounded. A long deep longitudinal fovea reaches to the top of the rear slope, which is steep.

The rear row of *eyes* viewed from above is recurved, but procurved from in front; the median eyes their diameter apart and rather more than three times that distance from the laterals, which are of the same diameter. Of the shorter front row, the laterals are as large as those of the rear row, but the median are

two-thirds their diameter. These are all equidistant, the diameter of the median apart, and one and a half of the same from the corresponding eyes of the rear row.

The *clypeus* is the width of the front median eyes to the margin of the beheaded part, and there is an equal distance of smooth muscle to the insertion of the mandibles.

The *mandibles* are much kneed at the base, narrowing to the anterior end, thickly covered with bristly hairs. The fangs are long and powerful. On the inner margin of the falx-sheath are three large equal teeth, and one large between two smaller on the outer.

The *lip* is longer than broad, hollow in front, rounded at the sides, and constricted at the basal part, which is rather long. It is more than half the length of the maxillæ, which are narrow at the base and gradually wider to the upper margin, where they are broadest, curving gradually on both inner and outer sides.

The *sternum* is a broad shield-shape, slightly convex, pointed at the rear between the nearly touching coxæ. It is thickly covered with upstanding bristly hairs.

The *legs* are stout and moderately long. The trochanters have a median ring of bristles rising from a chitinous ridge. The tibiæ and metatarsi have long powerful spines, with a bunch at the anterior end of the latter. There are thick scopulæ on the tarsus and metatarsus of all legs. The two claws have five or six pectinations.

The *palp* of the female has a pair of long spines at the base of the distal joint; the claw is smooth.

The *abdomen* is ovate, pointed at rear end, and the spinnerets terminal. The inferior pair are conical, two-jointed, the second joint being short and hemispherical. The superior pair are cylindrical, half the length of the inferior, with similar second joints.

The measurements (in millimetres) are as follows:—

Female.

		Long.	Broad.				
Cephalothorax ...		8	$\left\{ \begin{array}{l} 3 \text{ in front.} \\ 5\frac{1}{2} \\ 7\frac{1}{2} \end{array} \right.$				
Abdomen		11					
Mandibles.....		$3\frac{1}{2}$					
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	2	$6\frac{1}{2}$	7	$6\frac{1}{2}$	=	22
	2.	2	$5\frac{1}{2}$	$6\frac{1}{2}$	$6\frac{1}{2}$	=	$20\frac{1}{2}$
	3.	2	6	$5\frac{1}{2}$	6	=	$19\frac{1}{2}$
	4.	2	$6\frac{1}{2}$	7	$8\frac{1}{2}$	=	24
Palpi	1		$3\frac{1}{2}$	2	$2\frac{1}{2}$	=	9

One male and one female collected by Mr. R. N. Hawkes on Mt. Peel, Canterbury, at an altitude of 2000 feet.

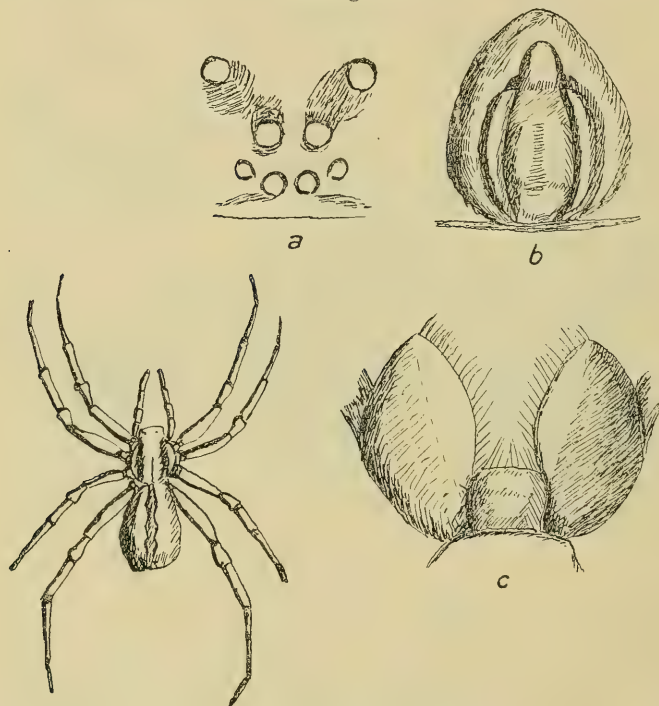
One male from Wellington, collected by Miss B. D. Cross.

Besides being twice as large, this species differs from *Uliodon* (*Zora*) *frenatum* L. Koch, from the same province, in the longitudinal lines on the cephalothorax. It has no pattern on the abdomen, and the sternum is yellowish instead of black-brown. There is a scopula on the tarsus and metatarsus of all legs, instead of only on the front two pairs.

ARGOCTENUS AUREUS, sp. n. (Text-fig. 94.)

Female. The cephalothorax is bright yellow in the middle the whole distance from the eyes to the rear; this is bordered on the side slope with dark grey, almost black, reticulations, with parallel stripes of the same colour reaching to the margin. At

Text-fig. 94.



Argoctenus aureus. Female. $\times 2$.

a, eyes; b, epigyne; c, lip and maxillæ.

the margin itself, on the rear half, is a narrow band of yellow, and at the side of the eye-space is rather darker yellow. The whole is covered with short downlying white flat hairs, the rear fovea being black-haired. Behind the eye-space is a jet-black curved line passing on each side along the margin, and there are

two black patches on the clypeus, but the same thick white hairs. The mandibles are deeper yellow, with a black streak on the inner edge of each, reaching from the base almost to the point, where it is again yellow. The fangs are red-brown. The lip is grey, the maxillæ pale yellow, with broad nearly white margins on the inner side of the former and front of the latter. The sternum is dark yellow-brown, thickly covered with white hairs and grey bristles. The legs are pale yellow on the upper side, with a grey streak nearly the whole length of the under side on the femoral, patellar, and tibial joints; covered with white or pale greyish-yellow hairs. The scopulæ and claw-tufts are pale grey.

The abdomen is yellow-grey, with a brown median scolloped stripe, darkened at the edges, reaching from the base to the spinnerets. The whole rear part is rather darker with a reticulation of grey on the yellow, the stripe remaining darker still. The hairs are white, with the exception of a few upstanding brown ones on the stripe and at the base. The under side is greyish yellow, covered with white intermixed with short brown hairs. The hairs on the yellow spinnerets are brown.

The *cephalothorax* is convex, rounded at the sides and broadest a little in front of the rear end. The front part is about one-half the greatest width, and the sides of this, as far back as the rear row of eyes, are straight.

The *eyes* are in four rows. The second row, the laterals of the front row, being vertically just clear of the median first pair. These are all of the same diameter and half their width apart. The rear two pairs are again of equal size, one-third larger than the front, the median ones being one-third of their diameter apart and the same distance from the front laterals. The median are $1\frac{1}{2}$ times their diameter from the rear laterals respectively, and the latter are four times their diameter apart.

The *clypeus* is as broad as the front eyes.

The *mandibles* are kneed at the base, divergent, and at the anterior end half their width at the base. They are as long as the front of the cephalothorax is wide. There are two teeth on the inner margin of the falx-sheath, and three smaller on the outer.

The *sternum* is broad shield-shaped, straight in front and curving to a point between the rear coxæ, which are not quite contiguous. It is thickly covered with downlying flat hairs and upstanding bristles.

The *lip* is broader than long, rounded at the side and in front, where it has a broad sloping edge.

The *maxillæ* are convex, upright, and about three times the height of the lip. From their base they curve outwards on both inner and outer margins to a rounded upper end, so that they are broadest in the middle. They have a few short upright bristly hairs.

The *legs* are moderately fine, covered with long powerful spines. There is a thick scopula on the tarsus and metatarsus, and claw-tufts under the weak curved pair of claws. On tibiæ 1 and 2

are three pairs of spines on the under side, on metatarsus of same a pair of very long spines at the base underneath; and another about the middle at the side. On tibia 4 are three long spines on the upper side and three pairs on the under. On metatarsus 4 are two pairs on the under side, three long spines on the outer side, and three long single ones on the upper side.

The tibia and patella of the palp are of equal length.

The measurements (in millimetres) are as follows:—

		Long.	Broad.				
Cephalothorax ...		$3\frac{1}{2}$	{ $1\frac{1}{2}$ in front. 3				
Abdomen		$5\frac{1}{2}$	4				
Mandibles.....		$1\frac{1}{2}$					
		Coxa.	Tr. & fem.	Pat. & Metat. tib. & tars.			
Legs.....	1.	$1\frac{1}{4}$	4	$4\frac{1}{2}$	$4\frac{1}{2}$	=	$14\frac{1}{4}$
	2.	$1\frac{1}{4}$	4	$4\frac{1}{2}$	$4\frac{1}{2}$	=	$14\frac{1}{4}$
	3.	1	3	$3\frac{1}{2}$	4	=	$11\frac{1}{2}$
	4.	$1\frac{1}{2}$	5	5	$6\frac{1}{2}$	=	18
Palpi.....		$\frac{1}{2}$	2	2	$1\frac{1}{2}$	=	6

One female from Mt. Peel, Canterbury, collected by Mr. R. N. Hawkes.

This species would appear to be somewhat near *M. Simon's A. vittatus* from Noumea, but the median abdominal stripe extends the whole length, and is pale brown instead of intense black. The legs are more heavily bespined, and the femora, although streaked longitudinally, are not ringed with black.

MYNOGLENES CHILTONI, sp. n. (Text-fig. 95.)

Male. The cephalothorax is of a rather deep yellow-brown, darker brown in the striations, but paler again on the rear slope. The eyes are pale yellow. The mandibles bright yellow-brown with red fangs. Lip and maxillæ about the same as the mandibles. The sternum darker, and dingier, is covered with fine granulations. The legs are pale yellow all over, with fine brown hairs paler towards the extremities.

The abdomen, both on the upper and lower sides, is black-brown, scantily covered with fine recumbent brown hairs.

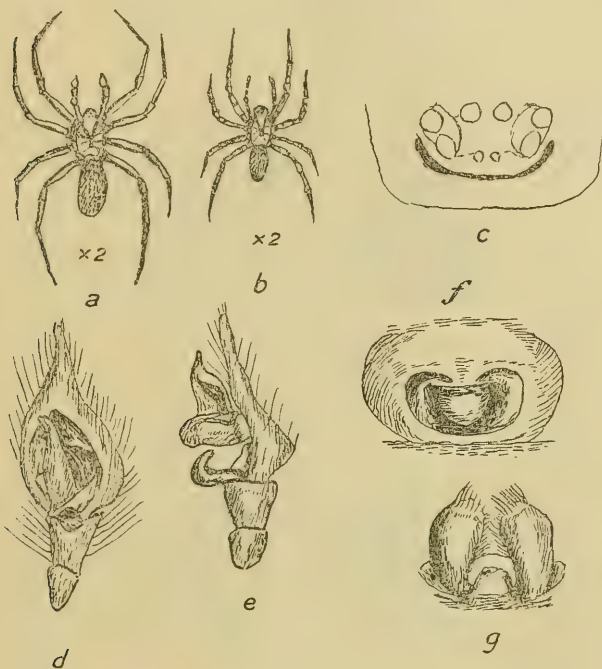
The cephalic part of the *cephalothorax* is slightly raised above the thoracic and rounded in front, where it is one-half the width of the broadest part, the latter being two-thirds of its total length. The surface of the thoracic part is smooth, without hairs, very finely granulated. The central fovea is shallow and round, with four pairs of small lateral furrows, and a broader and deeper pair round the margin of the cephalic part, all radiating from the fovea.

The *eyes* of the rear row are equal, the median their diameter apart, and the laterals one and a half diameters therefrom; these, with the front laterals touching them, lie on prominent tubercles.

The front median eyes, half the diameter of the others, are one-half of their own diameter apart; they are as far from the rear median as the latter from the side. The *clypeus* is as broad as the median eye-area is long, and the deep indentation characteristic of this genus runs below the front row of eyes.

The *mandibles* are much swollen in the upper half, whence they narrow and become almost cylindrical in their lower half; they are as long as the front of the head part is broad. On the outer margin of the falx-sheath are two long teeth followed by two smaller.

Text-fig. 95.

*Mynoglenes chiltoni*.

a, female; *b*, male; *c*, eyes; *d*, male palp from the front; *e*, male palp from the side; *f*, epigyne; *g*, lip and maxillæ.

The *lip* is broader than long, round at the top, with the protruding upper margin of the genus, and less than half the height of the maxillæ. These are upright, small at the base and gradually widen out as they curve over the lip.

The *sternum* is a broad shield-shape, straight in front, rounded at the sides and running to a point at the rear, where the coxæ do not quite meet. The latter are rather unusually large and rounded, especially the anterior pair.

The trochantal joints of the *legs* are long, and have a pronounced protruding ridge round them, about the middle. The other joints are thin and tapering, the tarsus and metatarsus being quite fine; they are well covered with very fine greyish-brown hairs, but have no spines.

The *abdomen* is long and oval, the surface being much corrugated longitudinally. The spinnerets are short, with a small hemispherical second joint.

Except in size the female agrees with the male.

The measurements (in millimetres) are as follows:—

Larger Male.

		Long.	Broad.			
Cephalothorax ...	3		{ 1 in front. 2			
Abdomen	4					
Mandibles	1½					
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	$\frac{3}{4}$	3	3	3½	= 10½
	2.	$\frac{3}{4}$	2½	2¾	3	= 9½
	3.	$\frac{3}{4}$	2¾	2	2¾	= 8½
	4.	$\frac{3}{4}$	3	3	4	= 10¾
Palpi		$\frac{1}{4}$	1½	$\frac{3}{4}$	$\frac{3}{4}$	= 3½

Female.

		Long.	Broad.			
Cephalothorax ...	2		{ 1 in front. 1½			
Abdomen	2					
Mandibles	1		1½			
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	$\frac{1}{2}$	2½	2	1¾	= 6¾
	2.	$\frac{1}{2}$	2	1½	1½	= 5½
	3.	$\frac{1}{2}$	1½	1½	1½	= 5
	4.	$\frac{1}{2}$	1¾	2	$\frac{3}{4}$	= 5
Palpi		$\frac{1}{4}$	1	1	$\frac{1}{4}$	= 3

This species differs from *M. marrineri* in the paler colouring of the mandibles, lip, maxillæ, and legs. There is no yellow pattern on the back, only a slight mottling, and no paler area on the under-side of the abdomen as in the foregoing. The thoracic fovea is short and shallow instead of being long and deep, and the granulated portions are confined to the thorax and sternum.

One male from the summit of Mt. Ngauruhoe, Waikato, N. Island. Mr. E. Phillips Turner.

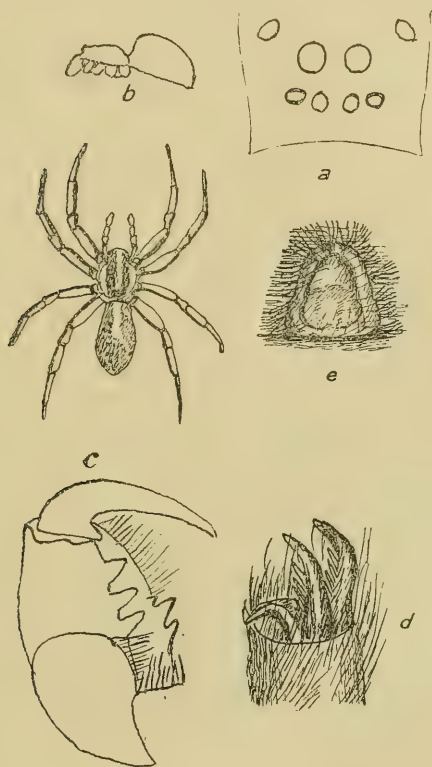
One male from Ruakura. Miss B. D. Cross.

One female from Picton in the South Island, found by Prof. Chilton, after whom I have named the species.

DOLOMEDES TRIDENTATUS, sp. n. (Text-fig. 96.)

Female. The cephalothorax is a bright chestnut, a broad area behind the eyes being thickly covered with silvery grey hairs, from this a narrower median streak of similar hair reaches to the rear slope, on each side of this is a broad area of chestnut covered with short orange hairs, and thence nearly to the side

Text-fig. 96.

*Dolomedes tridentatus*. Female.

a, eyes; *b*, profile; *c*, mandible from inside; *d*, tarsal claws; *e*, epigyne.

margin is again a broad white-haired streak. The mandibles are dark red-brown, thickly covered with long bristly hairs, nearly white on the outer sides, darker grey on the inner. The fangs are red. The lip, maxillæ, and sternum are dark brown, thickly covered with long upstanding brown hairs. The legs and palpi are bright orange, with long brown hairs darkening towards

the extremities of the limbs. The muscle parts are bright white. The abdomen is bright yellow-brown, thickly covered with short dingy yellow-brown hairs, a paler median stripe reaching from the base to about halfway down the back; on the sides of the abdomen the hairs are white. The underside is quite dark yellow-brown, with four longitudinal white-haired rather narrow stripes. The spinnerets are bright yellow-brown.

The upper surface of the *cephalothorax* although flat is considerably raised above the level of the side margins, and slopes steeply at the rear. It is one-fourth longer than its breadth in the widest part, and the front is only half the width of the latter. It is rounded at the sides and rear. There is a long and deep median longitudinal fovea extending from the cephalic part to the rear slope.

The side *eyes* of the front row are on the lower slope of black tubercles, which, extending farther back than the median eyes, give the appearance from above of a recurved row. Their lower edges are on a level with the lower edges of the median, and as they are smaller the line of the upper margins is really procurved. The median eyes are about their diameter apart and one-half that distance from the side pair, which are two-thirds of the width of the former. The eyes of the second row are about twice the diameter of the median eyes of the front row. They are rather less than their diameter apart, the same distance from the front median, and the total length is clearly less than that of the front row. The median eye-area is broader than long. The eyes of the third row are four-fifths the diameter of those of the second, five of their diameters apart, and two of the same from the eyes of the second row. The *chypeus* is about $2\frac{1}{2}$ times as broad as the front median eyes.

The *mandibles* are kneed at the base, stout, as long as the front of the cephalothorax is broad, and slightly divergent. They are thickly covered with long upstanding bristles. The fangs are broad at the base, strong, and well curved. About the middle of the inner margin of the falx-sheath are three large teeth, all equidistant, at the lower end of the outer margin is one large tooth between two small. The *lip* is broader than long, straight in front, and less than half the length of the maxillæ.

The *sternum* is a broad shield-shape, straight in front, pointed at rear, where it passes between the two rear coxæ, which are not quite contiguous.

The *legs* are stout and straight, slightly and normally tapering to the anterior ends, but in nowise fine or flexible; they are armed with numerous long and strong spines. There are scopulæ on the tarsi and metatarsi of the front two pairs, on the tarsi only of the rear. The superior claws have six or seven teeth, the inferior are smooth. There is a pair of spines on patellæ of pairs 3 and 4, none on patellæ of 1 and 2. The femoral joint of the palp

is incurved and enlarged at the anterior end, the tibial joint is longer than the patellar, and the female palp-claw has four pectinations.

The *abdomen* is oval, rounded at the sides. The hairs are smooth and fine. On the upper side are three pairs of muscle-spots. The *epigyne* is horseshoe-shaped, hollow in the anterior half only, and without any longitudinal rib. The superior pair of *spinnerets* is longer than the inferior. They are both two-jointed, the second joint half the length of the first.

The egg-sac is globular, white, and flocculent, 12 millimetres in diameter.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax ...	8	{ 3 in front. 6
Abdomen	11	6½
Mandibles.....	3	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	3	7	7	6½	=	23½
	2.	3	7	7	6½	=	23½
	3.	2½	6½	6½	6	=	21½
	4.	3	7	8	8	=	26
Palpi		1½	3	3	2½	=	10

One female from Dunedin. Collected by Mr. G. M. Thomson.

This species differs from the accepted limits of the genus *Dolomedes* as detailed by M. Simon in having three teeth only on the inner margin of the falx-sheath instead of four. The clypeus while broad is less broad than the area of the median eyes, and the patellæ of legs 1 and 2 are without spines. It is, however, much nearer to *Dolomedes* Latreille than to *Thaumasia* Perty, *Drances* Simon, or any other genus. I would have felt it right to propose a new genus for it on the above differences but for the fact that it graduates so imperceptibly into other members having four teeth, notably *D. huttoni* and *D. trippi* from the Chatham Islands, which are certainly *Dolomedes*. Its eyes and clypeus, the equality of the 1st and 2nd pairs of legs, and the marking of the cephalothorax in the female correspond almost exactly with those of *D. trippi*. Its epigyne is of the same type as that of *D. huttoni*.

EXHIBITIONS AND NOTICES.

February 21, 1911.

Dr. A. SMITH WOODWARD, F.R.S., Vice-President,
in the Chair.

THE SECRETARY read the following report on the additions made to the Society's Menagerie during the month of January last:—

The registered additions to the Society's Menagerie during the month of January were 121 in number. Of these 63 were acquired by presentation, 17 by purchase, 32 were received on deposit, 5 in exchange, and 4 were born in the Gardens.

The total number of departures during the month, by death and removals, was 160.

Amongst the additions special attention may be called to the following:—

2 Lion Cubs (*Felis leo*), from the Sebakwe River, S. Rhodesia, presented to the King's South-African Collection, through H.R.H. The Duke of Connaught, K.G., by Col. Weston Jarvis. Deposited by H.M. THE KING on Jan. 14th.

1 Jaguar (*Felis onca*), born in the Gardens on Jan 24th.

2 Bay Duikers (*Cephalophus dorsalis*), from Coomassie, presented by Capt. S. H. Chapin on Jan 21st.

2 Virginian Deer (*Dorcelaphus americanus*) ♀ ♀, from North America, purchased on Jan 17th.

1 Nacunda Nightjar (*Podager nacunda*), captured at sea off the coast of Brazil, new to the Collection, purchased on Jan 2nd.

1 Bornean Fireback Pheasant (*Lophura ignita*), presented by H.G. The Duke of Bedford, K.G., Pres.Z.S., on Jan 21st.

Dr. H. HAMMOND SMITH, M.R.C.S., F.Z.S., exhibited three skins of male Pheasants assuming female plumage, sent to him by Mr. Arthur Gilbey, and some microscopical specimens of the glands prepared by Dr. S. G. Shattock.

Mr. G. A. BOULENGER, F.R.S., V.P.Z.S., contributed a paper based on a collection of Fishes from the Lake Ngami Basin, Bechuanaland, made by Mr. R. B. Woosnam, F.Z.S.

This paper has been published in the 'Transactions.'

Mr. ALFRED H. COCKS, M.A., F.Z.S., exhibited a series of photographs of the female Brindled Gnu recently born in the Society's Gardens, and gave the following account of its growth and coloration:—

"On receipt of the orphan calf of the Brindled Gnu, born in

the Gardens on the 1st December last, which was brought to me on the 3rd, I was struck by the great difference between her and the drawing by J. Smit in P.Z. S. 1900, Plate xlviii. (facing p. 771), representing another calf previously born here; that figure, and one in 'Illustrations of the Zoology of South Africa,' &c., by Andrew Smith, M.D., London, 1849, No. 16, Aug. 1842, Plate xxxvii. *, being, I believe, the only two existing of a Gnu calf of this species.

Text-fig. 97.



Young Brindled Gnu born in the Society's Gardens on December 1, 1910.

From a photograph taken on January 7, 1911.

"What seemed specially worthy of note was that the tail for the proximal two-thirds of its length was white, as if the white-

* The beginning of A. Smith's description of the young is quaint: "Form and appearance clumsy and unseemly"!

tailed species were the older form. The body-colour was also quite different from that shown in Smit's plate, being of the lustreless ash-brown of an immature house-mouse, with a dull or rusty black dorsal stripe terminating in a point at the sacrum. The cheeks instead of being smooth and matching the body in colour, as shown in both the above-mentioned plates, were exactly the reverse. The dark colour on the outer side of the ears did not

Text-fig. 98.



Head of young Brindled Gnu.

From a photograph taken on January 7, 1911.

quite reach the margins, as if a man had taken a brushful of paint, and had given one streak to each ear, without afterwards making good the deficiencies. The lower two-thirds of all four legs was quite white; Andrew Smith's plate shows this conspicuously. The whole face was very dark or black, the black extending to a sharply defined width of about half an inch round the lower side of the eyes.

"By the 13th December (that is, when the calf was twelve days old), the whole of the upper side of the body was a *light fawn* (the original 'puppy coat' having been shed); the legs were gradually colouring, or less pure, or conspicuously white, than at first; and the colour was extending from above downwards. The white on the tail was already nearly gone. Face dark; nose and muzzle, as before, black; cheeks quite light, the dark ring remaining round the eyes. The coloration of the exterior of the ears as before.

"In Smit's plate the fawn of the body is darker, and more mixed with black-tipped hairs, and the drawing was evidently made at a greater age* than the present example attained to, not only for the reason just stated, but because the tail-tuft is of a brighter black, the dark circle round the eyes is shown as the faintest possible shadow, and the general figure of the animal is more set; but the most important discrepancy—which seems only explicable on the supposition that the present example belonged to a local race widely differing from the two calves previously figured,—is that both plates show quite a smooth cheek, whereas the present example, like her father (and I feel sure the mother was the same), had a perfect and very conspicuous 'Newgate fringe,' consisting of a woolly moustache, like a poodle's, but situated about halfway along the gape, and quite distinct from the moustachial bristles on the muzzle, meeting bushy whiskers on the cheeks, and continued as a long thick beard on the chin; the whole cheek was hirsute, or covered with long hairs projecting in a more or less upward direction.

"By the 16th the horns were appearing through the skin, and she had cut some molar teeth, which we could hear her grinding, so we tied up a wisp of hay, and she very soon learnt that it was good to eat. The tail now much resembled that of the Grey Squirrels so familiar in the Park, with the addition of a black tuft.

"By the 27th the dark ring below the eyes was fading away.

"On the 14th January the horns were about an inch long; and on the lower surface of the chin, between lip and Newgate fringe, but hardly extending to the side face, was a white patch, which I had not previously noticed.

"On the 15th the calf appeared as vigorous and in as perfect health as ever, but on the morning of the 16th she lay prostrate, and in a very short time was dead; the cause, as decided by Mr. Plimmer, the Society's pathologist, being broncho-pneumonia.

"The Gnu was photographed, by myself, on December 13, on December 31 and January 2, by Press photographers, and on January 7, by request of Dr. Chalmers Mitchell, by a Henley photographer; the series to some extent shows the growth.

* No hint is given (*loc. cit.*) as to the age of the calf when drawn, but it was born on July 14, and the drawing exhibited on November 20.

"I took the following measurements immediately after death:—
 Extreme length, tip of nose to tip of tail (= vertebræ), 4ft. $1\frac{1}{2}$ ins.
 Length of face, $11\frac{1}{8}$ ins.

" ear, $5\frac{3}{8}$ ins.

" tail (to end of vertebræ), 11 ins.

" fore leg (elbow to end of toe), $22\frac{7}{8}$ ins.

" hind leg (hock to end of toe), $15\frac{1}{4}$ ins."

PAPERS.

15. Report on the Deaths which occurred in the Zoological Gardens during 1910. By H. G. PLIMMER, F.R.S., F.Z.S., Pres.R.M.S., Pathologist to the Society.

[Received February 6, 1911 : Read February 21, 1911.]

On January 1, 1910, the number of animals in the Zoological Gardens was 3186, and during the year 2354 animals were admitted, making a total of 5540 for the year.

The number of deaths during the year has been 1554, that is a death-rate of 28 per cent.; but if from the above total we deduct 643 animals which did not live for six months after their arrival in the Gardens—that is, roughly, the time at which we find they have either got over their journeys, or died from any disease they brought with them, or have got entirely used to their new environment—the percentage of deaths is reduced to 16·4, which is less than that of the last two years.

The following figures will show the general relations of the last three years:—

	1908.	1909.	1910.
Total number of animals	5608	5303	5540
Total deaths	1737	1492	1554
Percentage of deaths	31	28	28
Percentage of deaths, excluding those which occurred in animals which had <i>not</i> been six months in the Gardens	17	17·8	16·4

If we consider the weather conditions of 1910, and compare these figures (bearing in mind the relative number of animals), it will be seen that the percentage of deaths of 1910 is more satisfactory than that of the two preceding years.

The total deaths are divided as follows: Mammals 362, Birds 845, Reptiles 347.

The following tables show the facts ascertained in outline. Table I. sets forth the actual causes of death in each of the three groups specified. Under Reptiles are included Batrachians and Fishes.

TABLE I.—Analysis of the Causes of Death.

Disease.	Mammals.	Birds.	Reptiles.	Reference to Notes following.
<i>1. Microbic or Parasitic Diseases.</i>				
Tuberculosis	18	163	9	1
Mycosis	13	99	6	2
Pneumonia	31	73	82	3
Septicæmia	7	...	...	4
Abscess	1	2	...	5
Pleuritis	1	...	...
Empyema	2	...	...
Pericarditis	6	6	1	6
Peritonitis	6	2	...	
Stomatitis .....	...	2	3	
Hydatids	3	...	...
Worms	1	9	6	7
Hæmogregarines .....	...	...	16	
Malaria .....	...	8	...	8
Coccidiosis .....	...	...	1	
Leucocytozoon infection .....	...	1	...	9
Cystitis	1	...	...
Pancreatitis .....	...	1	...	
<i>2. Diseases of Respiratory Organs.</i>				
Bronchitis	3	...	...
Broncho-pneumonia	50	...	...	10
Congestion of lungs	41	112	14	11
Atelectasis	2	...	...
<i>3. Diseases of the Heart.</i>				
Dilatation of heart	2	...	...
Fatty degeneration	2	7	...	
<i>4. Diseases of Liver.</i>				
Fatty degeneration	3	15	1	
Hepatitis	1	4	1	
<i>5. Diseases of Alimentary Tract.</i>				
Over-distension of crop .....	...	2	...	
Gastritis	2	...	1	
Gastric ulceration	8	1	...	
Gastro-enteritis	19	3	10	12
Enteritis	32	186	27	13
Intussusception	6	...	...	14
Intestinal obstruction .....	...	2	...	
<i>6. Diseases of the Urinary and Reproductive Organs.</i>				
Nephritis	22	12	...	
Stone	1	...	...	15
Inflammation of oviduct .....	...	3	...	
<i>7. Diseases of Nervous System.</i>				
Myelitis	2	1	...	
<i>8. Various.</i>				
Carcinoma	5	...	...	16
Sarcoma	3	2	...	17
Puerperal eclampsia	1	...	...
Senile decay	1	1	...	
Rickets	2	1	...	
Leukæmia .....	...	1	...	18
Anæmia without ascertained cause .....	...	1	...	
Injuries discovered <i>post-</i> <i>mortem</i>	3	16	2	

Besides those tabulated above,

113 animals were killed by order or by companions,

101 „ died of starvation and malnutrition,

7 „ were not examined,

108 „ were too stale for detailed examination,

these completing the total.

In Table I. the classification is made into those diseases which actually caused the death of the animals, but in a large number of Mammals, Birds, and Reptiles other lesions were present which helped towards the fatal issue, and these are classified in Table II. If taken together with Table I. a much more accurate estimate of the amount of disease in the Gardens will be arrived at.

TABLE II.—Other Diseases found in the Animals tabulated in Table I.

Diseases.	Mammals.	Birds.	Reptiles.	Reference to Notes.
Tuberculosis	12	34	8	19
Mycosis	1	8	...	
Pneumonia	6	15	5	
Stomatitis	2	...	...
Worms	8	...	14	
Peritonitis	8	2	...	
Pericarditis	14	3	3	
Empyema	1	...	...
Trypanosomes .....	...	2	1
Hæmogregarines .....	...	...	21
Malaria .....	...	12	...
Pancreatitis .....	...	7	...
Pleuritis	2	...	...
Filarie	4	36	5	
Cystitis	1	...	...
Bronchitis	2	20
Broncho-pneumonia	5	...	...
Congestion of lungs	26	51	4	
Collapse of lungs	12	...	...
Edema of lungs	3	48	10	
Hydrothorax	4	...	1	
Dilated heart	22	6	...	
Fatty heart	1	3	1	
Fatty liver	5	48	2	
Hepatitis	1	3	...	
Gastritis .....	...	1	3
Gastric ulceration	6	1	...	
Gastro-enteritis .....	...	...	5
Enteritis	12	29	13	
Intestinal obstruction .....	...	3	...
Nephritis	13	14	...	
Ascites	1	7	...	
Osteo-arthritis	1	...	...
Rickets	23	2	...	

TABLE III.—Shows the Distribution of Diseases causing Death amongst the principal Orders of Mammals.

Diseases.	Primates.	Carnivora.	Rodentia.	Ungulata.	Edentata.	Marsupialia.
Tuberculosis.....	7	7	...	3	...	...
Mycosis .....	...	1	...	5	...	7
Pneumonia	8	5	10	4	...	4
Septicæmia	1	2	...	3	...	1
Pleuritis	1	...	...	...	...	...
Abscess .....	...	1	...	...	...	...
Empyema .....	...	2	...	...	...	...
Pericarditis	1	...	2	3	...	...
Peritonitis .....	...	2	...	4	...	...
Hydatids	1	...	...	2	...	...
Worms .....	...	1	...	...	...	...
Cystitis	1	...	...	...	...	...
Bronchitis .....	...	2	...	1	...	...
Broncho-pneumonia	15	6	8	9	6	6
Congestion of lungs	16	7	10	1	3	4
Atelectasis .....	...	...	...	2	...	...
Dilatation of heart	1	1	...	...	...	...
Fatty heart .....	...	...	1	1	...	...
Fatty liver	2	...	...	...	...	1
Hepatitis .....	...	...	1	...	...	...
Gastritis .....	...	...	1	1	...	...
Gastric ulceration	4	3	...	...	...	1
Gastro-enteritis	1	15	1	1	1	...
Enteritis	12	8	3	2	...	7
Intussusception	3	...	1	...	...	2
Nephritis	7	5	6	2	...	2
Stone .....	...	...	1	...	...	...
Myelitis .....	...	2	...	...	...	...
Carcinoma.....	...	...	...	1	...	4
Sarcoma .....	...	...	1	2	...	...
Eclampsia .....	...	1	...	...	...	...
Senile decay .....	...	...	...	1	...	...
Rickets	2	...	...	...	...	...
Injuries	1	1	1	...	...	...

As Tuberculosis and Mycosis have again been the cause of a large number of deaths amongst the Birds, the following Table has been drawn up to show the relative incidence in the various Orders.

TABLE IV.—Showing the Comparative Incidence of Tuberculosis and Mycosis in the various Orders of Birds.

Orders.	Tuberculosis.	Mycosis.
Passeres	69	22
Picariæ	30	17
Psittaci	12	6
Anseres.....	2	8
Columbæ	16	6
Gallinæ.....	19	16
Striges	12	18
Laridæ	1	5
Struthionæ	2	1

Notes on the foregoing Tables.

The following Notes refer to some points of special interest which it was not possible to include in the tables :—

1. It will be noticed that there has been about the same percentage of tubercle as last year amongst the Mammals and Reptiles; that is, it has been found in 10 per cent. of the Mammals and 4·9 per cent. of the Reptiles examined. In the Birds, however, there has been an increase of 107 cases; that is, it has been found in 24·9 per cent. of those examined. This increase amongst the Birds has been partly due to an epidemic which occurred in the New Bird House in the beginning of the year. This was dealt with by entire disinfection of the house, and some structural alterations which have greatly improved it; a very definite improvement has taken place, but the arrangement of the cages at the ends of the house, and overcrowding generally amongst the Birds, is a constant source of danger.

Amongst the Mammals 2 cases have been of bovine type, and amongst the Birds there have been 7 cases of this type.

The liver of a *Tantalus* showing this particular type has been sent to the Museum of the Royal College of Surgeons.

2. Mycosis (under which term several distinct mould-diseases are grouped) has also increased among the Birds to a considerable degree—107 cases as against 48 last year.

The Mammals dying from this disease have been principally Wallabies and Gazelles. The disease (formerly grouped under the Septicæmias) has been found to be caused by a mould which enters through the mouth and produces abscesses about the jaws and in the adjacent muscles, and eventually a septicæmia.

It has also been found that a disease of the eye in Birds is due to a mould. It commences as a keratitis, and then pus is formed in the anterior chamber, and secondary abscesses form, from which the bird dies. Of the division headed Reptiles 3 were fishes with a mould-disease of the skin which invaded the muscles.

3. The increase of pneumonia amongst the Reptiles (87 cases as against 64 last year) has been mainly due to the variable temperatures in the Reptile House, owing to alterations in the heating apparatus. Only 3 of these cases were due to the presence of worm-eggs and embryos. There has been a decrease amongst the mammals and birds.

4. Five of these cases followed injuries: the remaining two were in Wild Swine, where it was caused by an organism belonging to the group producing Hæmorrhagic Septicæmia.

5. The one Mammal was a Fox with suppurative in the middle ear and destruction of the semicircular canals.

6. In an Antelope the pericarditis was due to numbers of worm-cysts on the visceral pericardium, which, so far as I know, is unique. In the Birds it was mostly due to the deposition of uric-acid crystals in the pericardium.



SALAMANDRA MACULOSA.

var. tenebrosa.

var. molleri.

forma typica.

of Green del. et Chromo lith.

7. In the Mammal—an Aardwolf—the worms were encysted pentastomata, which were in large numbers all over the body, causing pleuritis and peritonitis. In the Birds they were mostly syngamus.

8. Under Malaria are grouped cases in which intracorpuseular parasites belonging either to the *Halteridium* or *Proteosoma* group have been found in sufficient numbers to cause death.

9. In a Bulbul in which 60 per cent. of the polynuclear leucocytes were infected. This I believe to be new.

10. Most of these occurred during the first and last three months of the year; 4 of them were badly rickety.

11. Nine of the Mammals had bad rickets also. The number of cases amongst Birds, in which it is relatively much more fatal, is slightly less than last year.

12. In most of the Mammals it was caused by food-poisoning, in others, and in the Birds and Reptiles, by worms burrowing into the mucosa.

13. In 7 Mammals, 59 Birds, and 1 Reptile the enteritis was hæmorrhagic; in 6 Birds and 6 Reptiles it was due to worms; and in 9 Birds and 1 Mammal it was due to foreign bodies. This disease is a little less prevalent than last year.

14. Two very extreme intussusceptions occurred in two Wombats, recent arrivals, which came together.

15. In a Coypu Rat, in which 27 stones were found.

16. Four of these cases of cancer were in Wallabies, the stomach in all was the seat of the primary growth; the fifth was in a Markhoor in the mouth.

17. Two Gazelles died from sarcoma, one of liver and one of mediastinal glands.

18. This occurred in a Jungle-fowl and was of the splenomedullary variety.

19. In a Partridge and Marsh-Bird, both not described before.

20. In a Bat, in which all the wing-joints were affected.

16. A Contribution to the Study of the Variations of the Spotted Salamander (*Salamandra maculosa*). By EDWARD G. BOULENGER*.

[Received December 10, 1910: Read February 21, 1911.]

(Plate XV.† & Text-figures 99-102.)

The experiments now being carried out in Vienna by Dr. Kammerer on the colour-changes of the Spotted Salamander (*Salamandra maculosa*) in relation to its environment are attracting attention, and it has occurred to me that a general survey of what is known of the varieties of this very variable species, especially in connection with the geographical distribution,

* Communicated by G. A. BOULENGER, F.R.S., V.P.Z.S.

† For explanation of the Plate see p. 347.

would not be without importance at the present moment. Such a survey would afford those who wish to follow the path opened up by Dr. Kammerer a more precise basis than can be obtained from the available literature on the subject. I have therefore, with the help of my father, undertaken a revision of the rich material in the British Museum and have now the honour of offering an account of it for publication to the Zoological Society.

One of the principal results of my study has been to lay greater stress on the disposition of the markings than on their actual size, form, or colour, and to define two principal forms in Central Europe, which previous authors have not separated with sufficient precision, in spite of their well-marked geographical segregation.

Except in the case of var. *molleri*, with its aberrant coloration, authors dividing *S. maculosa* into a number of subordinate forms have dwelt on real or supposed structural characters, whilst ignoring the disposition of the markings. Bedriaga (3, p. 98), the most recent writer on the subject, recognizes, apart from the typical form, also called by him var. *europæa* (2, p. 252), three varieties, namely—var. *algira*, var. *corsica*, and var. *molleri*, the two former based only on slight structural differences, which are, besides, not constant, as I intend to show further on. Under the designation of typical form authors have generally thrown together specimens with different styles of markings, either simply observing that these are subject to infinite variation or classifying them under a number of titles, which refer merely to individual variations, such as the var. *tæniata*, var. *quadringata* and var. *nigriventris*, proposed by Dürigen (10, pp. 577 & 578) for certain individuals. In order to avoid introducing a new name, I will adopt the first of these for the assemblage which I have endeavoured to define and contrast with the typical spotted form on which the name *maculosa* is based.

To better bring out the individual differences to which the markings are subjected in this Salamander, I have drawn up tables of a certain number of the specimens in the British Museum, upon a scheme which should prove of use to those making experiments on the colour-changes, as by that means a record of each individual specimen, out of a large number, can be kept in such a way as to ensure its future identification. Such tables, explained by the annexed diagram (text-fig. 99), do not, however, convey an exact representation of the markings, which can only be done by descriptions, but they will be found to answer well enough for the purpose of identification.

In defining the varieties into which the species *Salamandra maculosa* may be divided, I have not lost sight of occasional exceptions, and have duly pointed them out. There are always exceptions, especially when we have to deal with forms of sub-specific rank, but such as I have come across are too few to militate against the adoption of a var. *tæniata* as opposed to the forma *typica*.

In the tables the explanation of the various columns is as

follows:—The length of each specimen (in millimetres) is taken from the end of the snout to the posterior extremity of the vent.

O means presence (+) or absence (—) of the supraocular spot (on the upper eyelid).

P, the spot on the parotoid gland.

Text-fig. 99.

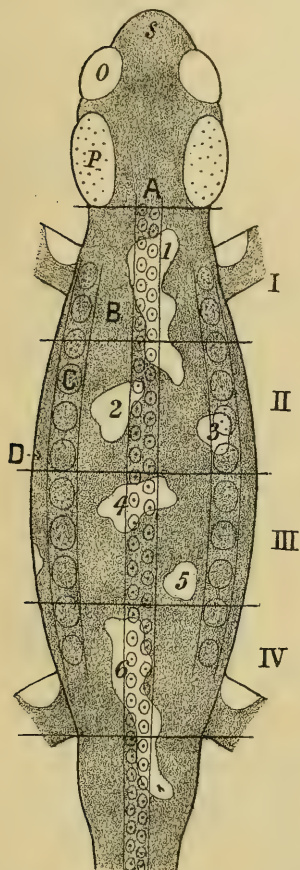


Diagram to explain the tables of different markings in *Salamandra maculosa*.

G, presence (+) or absence (—) of yellow spots on the chin and gular region.

V, on the ventral region of the body.

S, spot or spots on the snout.

OP, OS, whether the above-mentioned spots are confluent or not. PB, whether or not the spot on P is confluent with one on the body. In cases where the two sides differ, the initials R (right) and L (left) indicate the discrepancy.

Sp., total number of spots on the upper surface of body (to a line connecting the posterior borders of the hind limbs), which is divided into four conventional segments, numbered I, II, III, IV; under each of the latter figures, the spots pertaining to each segment are given. These spots are numbered 1, 2, 3, &c., in the order shown on the diagram; in case of absolute symmetry, the spots are numbered from right to left.

A stands for the vertebral area, bearing the two median rows of glands. B (right and left) for the area between A and C; C (right and left) for the area occupied by the series of large lateral glands; D for the area between the latter and the limit of the belly (taken from an imaginary line connecting the lower border of the axil with the groin). In column D, right and left sides are separated by a —, the figures referring to the number of spots on each side (spots confluent with the ventrals and dorsals not reckoned), not to the individual spots as in the columns A to C.

The tabulation of the markings on the specimen represented in text-fig. 99 may be drawn up as follows:—

SECTION.											AREA.				
O	OP	P	PB	S	OS	Sp.	I.	II.	III.	IV.	C	B	A	B	C
+	—	+	—	—	—	6	1	1.2.3	4.5	6	—	1.2.4.6	1.2.4.6	1.3.4.5.6	3

The following is a list of the specimens preserved in the British Museum and the Lataste Collection, arranged geographically under varieties:—

FORMA TYPICA.

France.

1. ♂.	Beure, near Besançon.	Mme. Phisalix.
2. ♂.	Avignon.	M. M. Mourgue.
3. ♀.	Basses-Alpes.	M. Honnorat. Lataste Collection.
4. ♂.	S.E. France.	Prof. Duboseq.

Corsica.

5-9. ♀ & yg.	Bocognano.	Dr. J. de Bedriaga.
10. Yg.	Vizzavona (1100 m.).	Prof. Vayssière.
11. Yg.	Corsica.	Dr. J. de Bedriaga. Lataste Collection.

Germany.

12. ♂.	Near Stuttgart.	Prof. K. Lampert.
13. ♀.	Ballenstadt, E. Harz.	Dr. W. Wolterstorff.
14-15. ♂ ♀.	Sharfenberg, near Meissen, Saxony.	"

Switzerland.

16-17. ♂ ♀.	Near Lausanne.	W. Morton, Esq.
18. Hgr.	Flüelen, Uri (465 m.).	M. A. Ghidini.
19. ♂.	Lugano, Ticino (275 m.).	"
20. ♂.	Val Bavano at Caveragno, Ticino (ca. 600 m.).	"

Italy.

21. ♂.	Prego, Brianza, L. Como.	Dr. C. Vandoni.
22. ♀.	Tuduno Olona, Varese.	"
23-24. ♀.	Olginate, Prov. Lecco, Lombardy.	"
25-54. ♂.	Cascinella, near Borgoli, Prov. Genoa.	Dr. R. Gestro.
55. ♂.	Viterbo.	Prof. J. J. Bianconi.
56-60. ♂ ♀.	Prov. Rome.	Prof. Carruccio.
61. ♀.	Aspromonte, near Reggio, Calabria (1600 m.).	Prof. O. Neumann.

Austria-Hungary.

62-63. ♂ ♀.	Hütteldorf, near Vienna.	Dr. F. Werner.
64-66. ♂ ♀ & yg.	Near Prague.	G. A. Boulenger, Esq.
67. ♀.	Brasso, Hungary.	Prof. L. v. Méhely.
68. Yg.	Teszla, Bozau Mts., Hungary.	"
69-88. ♂ ♀.	Nagy Becskerek, Hungary.	Hr. A. v. Kovács.
89. ♂.	Hungary.	"
90. ♀.	Sarajen, Bosnia.	Dr. F. Werner.
91-92. ♂.	Travnik, Bosnia.	"

Roumania.

93. ♂. Near Azu, Carpathians of M. A. Montandon.
Moldavia.
94-113. ♂ ♀ & yg. Sinaia, Carpathians of Vallachia. „

Greece.

114. Yg. Parnassus. Dr. T. Krüper.

Asia Minor.

115. ♀. Zebel Bulgar Dag, Cilician C. G. Danford, Esq.
Taurus (1200 m.).

Algeria.

- 116-118. ♀ & yg. Mt. Edough, near Bona. Dr. Hagenmüller.
119-122. ♂ ♀ & yg. „ „ „Lataste Collection.
123. Yg. „ „ M. L. Bedel. „
124. ♀. L'Arba, near Algiers. M. Lallemand. „
125. ♂. Algeria.

Morocco.

- 126-133. ♀ & yg. Benider Hills, near Tangier. M. H. Vaucher.

Vars. GALLAICA and MOLLERI.

Spain.

1. ♀. Vigo, Galicia. M. V. L. Scoane.
2-5. ♂ ♀ & yg. Galicia. „Lataste Collection.
6-11. ♂ ♀ & yg. Loroya Valley, near Madrid M. de la Escalera.
(300-400 m.).
12. Yg. Spain. Lord Lilford.

Portugal.

13. ♀. Coimbra. Dr. J. de Bedriaga.
14-17. ♂ ♀. „ „
18-19. ♂ ♀. Cintra. Col. Yerbury.
20. ♀. Near Lisbon. Sr. Mattozo Santos.

Var. TÆNIATA.

France.

1. ♀. Near St. Malo. G. A. Boulenger, Esq.
2-5. ♂ ♀. Roscoff, Finistère.
6-8. ♂ ♀ & yg. Near Rouen. M. Louis Müller.
9. ♀. „ M. L. Horst.
10. ♀. Armainvilliers, near Paris. M. E. Simon. Lataste Collection.
11-13. ♂. Haute-Marne. Dr. A. Pettit.
14-19. ♂ ♀. Beure, near Besançon. Mme. Phisalix.
20. ♀. Bourg-en-Gironde. Lataste Collection.
21-26. ♂ ♀. Hérault. Prof. Duboscq.
27. Yg. Aix-les-Thermes, Ariège. M. V. Baillet.
28. ♂. Eaux-bonnes, Basses-Pyrénées. Rev. F. A. Walker.

Belgium.

- 29-30. ♂ ♀. Maredsous, Prov. Namur. Rev. B. Lebbe.
31. ♂. Waulsort, „ G. A. Boulenger, Esq.

Luxemburg.

32. ♀.

Luxemburg.

M. V. Ferrant.

Germany.

53-40. ♂ ♀ & yg.

Iisenberg, Harz.

Dr. W. Wolterstorff.

41. ♀.

" "

W. H. Decks.

42-51. ♂ ♀.

Harz.

Zoological Society.

52-53. Yg.

" "

G. A. Boulenger, Esq.

54-55. ♂ ♀.

Vorwohle, Brunswick.

Dr. W. Wolterstorff.

56-58. ♂ ♀.

Holzminden, Brunswick.

" "

59-60. ♂ ♀.

Stadtoldendorf, Brunswick.

M. A. Ghidini.

61-63. ♂ & yg.

Lippe-Detmold.

Dr. J. Roux.

64-67. ♂ ♀ & yg.

Near Stuttgart.

Prof. K. Lampert.

68. ♂.

G. Duchy of Baden.

Basle Museum.

Switzerland.

69-72. ♂ ♀ & yg.

Langenbruck, Jura.

Basle Museum.

73. ♂.

St. Gallen.

M. A. Ghidini.

Portugal.

74-75. ♂ & yg.

Oporto.

E. Allen, Esq.

76-77. ♂.

Portugal.

P. B. Webb, Esq.

I. THE TYPICAL FORM.

This form deserves to be regarded as the typical, not only because the name *maculosa* applies best to it, but because it is the only one found in Austria (*cf.* Werner, 32, p. 119), where it was described under that name by Laurenti (18, pp. 42, 151). It also happens to be the form figured by most authors:—Aldrovandi (1, p. 641), Rösel (24, frontispiece), Latreille (17, pl. i.), Sturm (30), Reider & Hahn (23), Funk (12, pl. 1.), Bonaparte (5), Rusconi (25, pl. i.), and Camerano (6, pl. i.). It corresponds to the vars. A and C of Duméril and Bibron (9, p. 37), *a-c* of Schreiber (27, p. 75). In this form the black nearly always greatly predominates over the yellow, the latter appearing as markings of various shapes,—round, elongate, **C**-, **S**-, **Y**-shaped, &c., and disposed over the body, often in 3 to 5 alternating series, or with a median series forming a sinuous or zigzag vertebral stripe. If, as is very exceptionally the case, the dorsal spots appear to form two longitudinal series, it will be observed that they by no means hang together in regular chains continuous with the spots on the parotoids. Only in one specimen (from Lausanne) have I felt embarrassed as to the form to which it should be referred. Upper eyelid and parotoid usually entirely, sometimes only partially, yellow, the spots on the parotoid may even be entirely absent (specimens from Algeria and Morocco). The two spots thus located are, as a rule, distinct, but may occasionally run together. In a specimen from Nagy Begskerek, Hungary, the yellow markings on the upper eyelids extend across the interorbital region, forming a cross-bar. The sides usually bear spots, which may number up to 15, in which case they are, of course, very small. A spot above the angle of the mouth is absent in only about 5 per

cent. of the specimens. Gular region with a few large or small markings, sometimes completely unspotted. Below entirely black or with spots which are usually of small size, the only specimens with very large spots being single ones from Genoa, Viterbo, and Reggio in Italy. Snout generally entirely black. Limbs black, with a characteristic yellow blotch on the upper surface of the arm and thigh, near the base, which is constantly present; a second on the forearm and leg may or may not also be present. Hand and foot entirely black or with one or two (rarely more) yellow spots, which, as a rule, are not confluent with the spot on the forearm and leg. Single or paired spots on the tail, which may run together to form a stripe. Under surface of tail nearly always black.

Text-fig. 100.

*Forma typica.*

The colour of the bright markings varies from chrome-yellow to a deep orange. I have found traces of claret-red on the head in some specimens from Genoa. The usual absence of yellow on the snout has been mentioned above; the only exceptions I have noted are to be found in specimens from Lausanne, Avignon,

Corsica, Genoa (7 specimens out of 40), the province of Rome, and Calabria. The latter is remarkable for the large size of the yellow markings on the upper and lower surfaces, where they almost equal in extent the black area. The opposite extreme occurs in a specimen from the Val Bavano, Ticino, in which the yellow colour is reduced to a few very small blotches on the parotoids and at the base of the limbs. These two extremes are figured side by side in text-fig. 100.

On careful examination of the specimens of var. *algira* Bedriaga and var. *corsica* Savi, I have come to the conclusion that they are not essentially different from the forma *typica*.

The var. *algira* is described by Bedriaga (3, p. 111) as having the tail and digits longer and more slender than in the typical form; but the specimens from Mt. Edough (in the Lataste Collection), upon which Bedriaga based his observations, are in a rather emaciated condition, having, no doubt, been kept in captivity for some considerable time, and this is evidently partly the cause of their slenderness. Although the digits and tails of the Salamanders from Algeria and Morocco are, as a rule, longer than in the typical form, the longest digits in the latter may be actually longer in proportion to the length of the body. Thus, in a specimen from Lake Como, the length of the longest toe is $9\frac{1}{2}$ per cent. of the total length (from tip of snout to posterior end of vent), while in a specimen from Mt. Edough, Algeria, the length of the same is 9 per cent., and in one from the Benider hills, Morocco, as low as $6\frac{1}{2}$ per cent. Again, the length of the tail in var. *algira* ranges from 65 to 81 per cent. of the length of the body, against 54 to 78 in the forma *typica*, an overlap which precludes the character being used as diagnostic.

In the same author's description of the Corsican variety, the head is stated to be remarkably broad, and the toes to be much more strongly depressed and with sharper edges on the sides than in the typical form. I have examined the very specimen described by Bedriaga, but do not find the head to be any broader than in some of the typical and striated forms, and although the toes are more depressed than is generally the case, they are not more so than in certain specimens from Vienna, Bosnia, Luxemburg, and the Harz Mountains. As to the more sharply edged sides of the toes, this sharpness simply coincides with the degree of depression.

The supposed difference in the palatine dentition, on which *S. corsica* was founded by Savi (26), has long ago been disposed of by Schreiber (27), Bedriaga (2), and Camerano (6).

The habitat of the typical form seems to be bounded to the west by the Erz Mountains, the Danube, the Alps, and the Rhone, all the specimens from east and south of that line belonging to it, with a few exceptions mentioned below. All over France, west and north of the Rhone, the var. *teniata*, described further on, alone occurs (with rare exceptions from the Doubs), whence it extends to Northern Spain (Bilbao, *vide* Bedriaga) and Portugal (Oporto, Brit. Mus.).

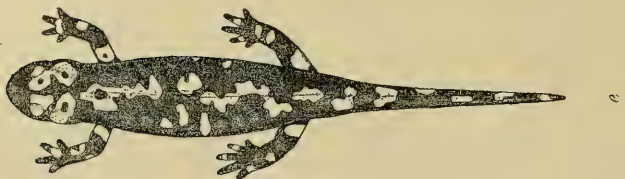
I. Forma typica.

SEX.	LENGTH	SECTION								AREA					D.	G.	V.					
		O	OP	P	PB	S	OS	Sp.	I.	II.	III.	IV.	C.	B.				A.	B.	C.		
1. ♂	161	+	-	+	+	+	-	9	1.2	3.4	5.6	7.9	5	1.4	4	2.3	4.7	4.3	3-1	+	+	+
2. ♂	100	+	+	+	+	+	-	4	1	1.2	2.3	4	3.4	1.3	1.4	1.2	2	2	4-3	+	+	+
3. ♂	127	+	+	+	-	+	+	23	1-6	7-11	12-17	17-23	2.13.15.18.20	3.9.12.13.17	3.5.8.12.13.21.23	3.11.14.21.22	1.4.6.7.10.16.18.22	7-8	+	+	+	
4. -	43	+	-	+	-	-	-	7	1.2	3.4	5.6	7	-	2.4	1.2	3.5	5.7	3-2	-	-	-	
5. ♂	100	+	+	+	-	-	-	9	1-3	2.4.5.6	6-8	8.9	6	2.6	6	1.3	4.6	5	5-2	+	+	+
6. ♂	95	+	+	+	-	+	-	13	1-3	4-8	6.9-11	12.13	8.11	2.4.6.9.12.13	2.7	1.3	5	3-3	+	+	+	
7. ♂	95	+	+	+	-	+	-	6	1.2	2	3-5	6	-	1.2	1.2	2.4	3	0-0	+	+	+	
8. ♂	95	+	+	+	-	+	-	6	1	1	1-3	4-6	-	-	1.3	2.4	3	2-3	+	+	+	
9. ♂	90	+	+	+	+	L	+	3	1.2	3.4	5	6	5.6	1.4	5.6	3	0-0	+	+	+	+	
10. ♂	80	+	+	+	+	+	+	3	1	1	1.2	3	-	1.2	1.2	1.3	-	0-0	+	+	+	
11. ♂	78	+	+	+	+	+	+	5	1	1.2	3-5	5	2.4	1.2	1.2	1.3	3.5	0-0*	+	+	+	
12. ♂	97	+	+	+	+	+	-	12	1-3	1.4	5-11	12	2.3	1.4	1.4	1.2	10	3-1	+	+	+	
13. ♂	111	+	+	+	+	+	-	14	1-3	3-5	6-10	11-14	6.7.12	1.3	3.8	4.6	2.4	2-4	+	+	+	
14. ♂	97	+	+	+	+	+	-	10	1.2	2-5	5-8	9.10	3.4	1.2	1.2	2.5	2.7	6-5	+	+	+	
15. ♂	91	+	+	+	+	+	-	5	1	2.3	4	5	-	1.2	-	3.4	3	0-0	+	+	+	
16. ♂	109	+	+	+	+	+	-	9	1-3	3.4	5.6	7-9	3.5	2.9	1.2	1.2	4.6	2-8	+	+	+	
17. ♂	105	+	+	+	+	+	-	9	1.2	3-5	6-7	8.9	-	2.6	3.6	1.3	4.6	4-4	+	+	+	
18. ♂	94	+	+	+	+	+	-	12	1.2	3-6	7-11	12	5.6	1.3	1.3	5.7	1-1	+	+	+	+	
19. ♂	101	+	+	+	+	+	-	7	1.2	3	4	5-7	1.4	1.4	1	3.6	2.6	3-4	+	+	+	
20. ♂	100	+	+	+	+	+	+	5	1.2	3	2	3.4	-	2.3	2.4	1.2	2	2-2	+	+	+	
21. ♂	100	+	+	+	+	+	+	7	1.2	3.4	5.6	6.7	-	2.3	-	6	3-3	+	+	+	+	
22. ♂	98	+	+	+	+	+	+	8	1.2	2.3	3-5	5-7	6	1.3	1.3	5.7	2-2	+	+	+	+	
23. ♂	97	+	+	+	+	+	+	8	1.2	3	4-6	7.8	-	2.3	3.5	6	2-0	+	+	+	+	
24. ♂	78	+	+	+	+	+	+	3	1	2	3	3	1.3	1.2	1.2	2	1-1	+	+	+	+	
25. ♂	133	+	+	+	+	+	+	7	1	1.2	4-6	6.7	2.3	1.3	1.6	4.6	12-14	+	+	+	+	
26. ♂	111	+	+	+	+	+	+	5	1	1.2	3	3-5	2	1.2	1.2	5	0-0	-	-	-	-	
27. ♂	97	+	+	+	+	+	+	5	1	2.3	4	5	-	1.2	1.3	-	7-5	-	-	-	-	
28. ♂	91	+	+	+	+	+	+	8	1.2	3.4	5.6	7.8	-	1.3	2.3	-	0-0	-	-	-	-	
29. ♂	96	+	+	+	+	+	+	10	1.2	1.3	4.5	6.7	8-10	3.5	1.7	1.7	2.4	3-4	+	+	+	
30. ♂	91	+	+	+	+	+	+	5	1	2.3	4	5	6	-	1.3	1.3	2	3-1	+	+	+	
31. ♂	81	+	+	+	+	+	+	6	1	2-4	5	6	3	1.2	1.2	1.5	0-0	+	+	+	+	
32. ♂	70	+	+	+	+	L	-	4	1.2	2.3	3	4	-	1.2	1.2	3.4	0-0	+	+	+	+	

* A large marking on the belly on the left side is confluent with spot No. 4 on the back.

1. A vignon.	5. Stuttgart.	8. Varese, Lombardy.	15. Brasso, Hungary.	25. Zebel Bulgar Daghi, Asia Minor.
2. Basses-Alpes.	6. Lausanne.	9-10. Rome.	16. Sarajevo, Bosnia.	26-28. Mt. Edough, Algeria.
3. Bocagiano, Corsica.	7. Lugano.	12-13. Hütteldorf, near Vienna.	17-18. Travnik, Bosnia.	29. Algeria.
4. Vizzavona, "	8. Varese, Lombardy.	14. Prague.	19-24. Shatin, Roumania.	30-32. Bender Hills, Morocco.

Text-fig. 101.

THE SPOTTED SALAMANDER. *Forma typica.*

All the specimens hitherto examined from Belgium, North-Western Germany, and the Rhine are referable to that variety, which also prevails in Würtemberg (*cf.* Leydig, 19). Exceptions to the above geographical division occur to my knowledge near, or

not far from, the line of demarcation, as on Mt. Salève in Savoy, according to M. Ghidini, but possibly also in Italy near Rome, where, according to Duméril, the striped variety has been found (yellow on the back, with three black stripes, and a few scattered black spots on the limbs and belly)*. Further, a specimen referable to the typical form from Ballenstedt, Anhalt, received from Dr. Wolterstorff, one from the neighbourhood of Stuttgart, received from Prof. Lampert, and six exceptional specimens sketched by Mme. Phisalix: five from near Besançon, black above with irregular yellow blotches on the back, and one from Toulouse (Paris Museum), yellow above and below with irregular black markings on the back, a very aberrant specimen. One of these specimens, from Beure, near Besançon, has been presented by Mme. Phisalix to the British Museum, and is listed under the head of forma *typica*, whilst six others from the same locality appear under var. *taniata*, thus showing that in the French Jura the latter variety is not so completely fixed as it appears to be in the North of France and Germany and Belgium.

Five specimens are represented on text-fig. 101:—

- a*, from Varese, Lombardy, is remarkable for its small amount of yellow, and for its long and thin yellow vertebral stripe, extending from the nape to over halfway down the back. Sides and lower surface with only a few spots.
- b*, from the Benider hills, Morocco, with a small number of large roundish spots on the back, has the left parotoid entirely black.
- c*, from Hütteldorf, near Vienna, has a remarkably large number of spots. Flanks and sides of belly spotted.
- d*, from the neighbourhood of Prague, is a type with very irregular markings. Flanks and sides of belly with only a few large spots.
- e*, from Zebel, Bulgar Dag, Asia Minor, has some of the spots ring-like, the yellow markings having a round black spot in the centre. Sides profusely spotted. Lower surface with many spots of small size.

The specimen figured on Plate XV. is a male from Lugano, Ticino, sent alive by M. A. Ghidini.

II. THE VARIETIES OF THE SPANISH PENINSULA.

(Vars. *gallaica* and *molleri*.)

We have mentioned above that the var. *taniata* occurs in Spain and Portugal. Specimens of that form, with the yellow colour predominating over the black, are stated to occur in the Peninsula by Schreiber (27, p. 78), and Bedriaga (3, p. 108)

* I am indebted to Mme. Phisalix for a sketch of this specimen preserved in the Paris Museum. It is not unlikely, however, that the locality under which it has been registered is erroneous, as neither de Betta (4), Camerano (6), nor Count Peracca (*in litt.*) have come across the striped variety in any part of Italy.

records such a one from Bilbao. But in addition we find highly remarkable specimens ranging from the form named var. *gallaica* by Seoane (29), which is hardly separable from the typical form, especially its North African representatives, to that named var. *molleri* by Bedriaga, which approaches very closely some specimens from near Genoa, from Austria, described by Kammerer (cf. p. 342), and from Oran, Algeria, described by Doumergue *. My father has already proposed to unite the var. *gallaica* with the var. *molleri*, a view in which Bedriaga (3, p. 109) could not concur, on the ground that Seoane's diagnosis does not at all agree with his own. It is, nevertheless, a fact that an almost uninterrupted series can be traced between the two varieties, and I think it advisable, provisionally at least, to regard them as extremes of one and the same form, which is completely linked with the typical form.

The following is a translation of Seoane's definition of the Spanish specimens (var. *gallaica*):—"Differs from the typical form, among other characters, in the intense black of the ground-colour and the small number of yellow spots, distributed over the body."

The three specimens from Galicia (*Seoane*) in the Lataste Collection are remarkable for the very irregular, broken-up disposition of the spots on the back, a few of which are partly brownish and may have been edged with red or pink, in a manner similar to Bedriaga's var. *molleri*. The snout, supraocular and interorbital regions, partly yellow, partly reddish brown; yellow on the throat somewhat predominating over the black; sides irregularly spotted with yellow. The number of spots on the dorsal region of these specimens is 9, 13, and 26 respectively. A specimen from Cabanas, Galicia (*Seoane*), preserved in the Paris Museum and of which a sketch has kindly been made for me by Mme. Phisalix, approaches very closely the Portuguese var. *molleri*. The British Museum specimen from Vigo differs, however, from all the above by being very scantily marked with

* Essai sur la Faune Erpétologique de l'Oranie (Oran, 1901), p. 372.

"Corps présentant en dessus plusieurs taches jaunes et rouges sans symétrie dont voici la distribution. Régions sus-oculaires jaunes en dessus et d'un rouge sang en avant et en arrière. Arcades sourcilières d'un noir rougeâtre. Parotides jaunes en dessus et aussi en dessous postérieurement, entourées de noir en avant; extérieurement elles sont bordées depuis l'œil jusque sur le cou, d'une longue et large tache rouge. Seules les taches des régions sus-oculaires et celles des parotides présentent quelque symétrie. Sur le cou se trouve une grande tache transversale échancrée en avant, à laquelle font suite, sur le dos, quatre taches irrégulières (de 7 mill. sur 3 en moyenne). Ces taches alternent entre elles et touchent la double ligne dorsale de tubercules; elles sont à peu près à égale distance l'une de l'autre. Près de l'aisselle, sur le bras, il y a une petite tache jaune bordée de rouge; une ou deux très petites, jaunes et rouges, se voient sur l'avant bras, et une seule sur les mains et les pieds. Le fond noir des flancs est parsemé de quelques points rouges. Membres postérieures tachés comme les antérieurs. En arrière de la ligne des cuisses, en dessus, commence une tache jaune, longue et étroite, qui s'étend en arrière; elle a 10 mill. sur 2 à 3. Sur la queue on voit cinq séries de taches doubles, rondes, qui se rapprochent l'une de l'autre sur la ligne médiane supérieure; elles sont jaunes et visiblement bien bordées de rouge, surtout celle placées vers le bout de la queue. Mamelon du cloaque taché de jaune de chaque côté. Dessous du corps d'un violet noirâtre. Pourtour inférieur de la bouche bordé de taches rouges qui s'étendent sur la gorge."

yellow, except on the gular region and on the sides of the belly. The back, snout, and interorbital region bear no distinct markings, but are speckled over with small yellowish dots. The parotoids and upper eyelids are almost entirely of a reddish-brown colour. This specimen must be regarded as an individual aberration of the form above described, an aberration tending to the total suppression of the bright markings.

Three specimens referable to the var. *gallaica* have been received from M. de la Escalera, who obtained them in the Loroya Valley, near Madrid, at an altitude of 300 to 400 metres. The spots are moderately large, few or moderately numerous (6 to 12), those on the parotoids being either confluent with or distinct from those on the upper eyelids and the dorsal region. The spot on the eyelid in one of these specimens is entirely of a reddish brown, that on the parotoid partly reddish, partly yellow. In this and another specimen the interorbital region is also reddish. The spot at the angle of the mouth in all three is brownish red in colour. Lower surface and sides black, minutely speckled over with yellow; throat spotted with red.

The true var. *mølleri* is represented in the British Museum Collection by 7 specimens from Portugal (Coimbra and Cintra), including one of the types received from Dr. de Bedriaga, who has thus described its coloration:—

“The colour and pattern of this variety are rather variable. The ground-colour is usually a greyish brown, sometimes more of a dirty grey, sometimes more brownish black or even black, broken up above and below by pale yellow spots with an addition of grey or greyish-brown spots into which the yellow passes gradually. The yellow spots on the side of the body, on the limbs, on the tail, on the parotoids, on the throat, and on the eyelids are as if powdered over with red dust, or washed with red, or even blood-red. The throat may sometimes acquire a deep red colour; the dorsal spots show here and there a red dot. The yellow spots are very variable both in number and size; they may be either few, in which case they are large and roundish, or numerous and horseshoe- or ring-shaped, and forming six or eight more or less regular longitudinal series; some of these spots break up or run together, thus forming wavy bands. These spots may be so numerous as to greatly reduce the ground-colour; the yellow spots on the head are in that case the more conspicuous and a symmetrical or very ornamental pattern results.”

My father has drawn up the following notes on living specimens exhibited in our Zoological Gardens, a few years ago.

“Some specimens were black, variegated with various tints of grey, brown, pale yellow, and crimson. The latter colour was particularly conspicuous on the upper eyelids, the parotoid glands, the base of the limbs, and on the throat, but it appeared also as small patches within the area of the more or less irregular pale yellow spots with grey centres, which were disposed very irregularly on the body and tail. One of the specimens was pale

olive-grey above and on the sides, freckled with black and with pale greenish-yellow spots; the black appeared as an irregular vertebral stripe, a dorso-lateral stripe, and bars on the flanks; the upper eyelids, the parotoids, and the throat were claret-red. The coloration of such a Salamander has a lichen-like aspect more suggestive of assimilation to the surroundings than of warning to enemies." Other specimens which he has seen since had but little or no red on them, but the yellow spots were greyish in the centre.

In his description of var. *molleri*, Bedriaga states that it differs from the typical form in the snout being more pointed and projecting beyond the lower jaw, also that the tail is shorter and thicker. In five out of eight specimens (including Bedriaga's type) examined by me, I found the snout to be more projecting than is usual in the other forms, although the most pointed snout I have seen is in a specimen from near Meissen, Saxony. I also found that the tail in four out of the eight specimens was stouter and shorter than usual in the typical form and the var. *teniata*, and this is also to be noticed in the figure on Pl. XV. The length of the tail in each of the specimens (measured from the posterior end of the vent) was 55, 55, 57, 57, 63, 67, 67, 71, the length of the body being taken as 100 (tip of snout to posterior end of vent). The length of the tail in the typical form varies from 60 to 78, with an average of about 67, whilst in the var. *teniata* it may fall as low as 54 (Besançon). It will be seen therefore, that there are many exceptions, and too much importance should not be attached to this character. I may add that the measurements of the Galician specimens, alluded to above under the name of var. *gallaica*, give 57, 66, 70, and 70 as the length of the tail, and those of the specimens from near Madrid 56, 65, and 70.

Thanks to the courtesy of the Hon. Walter Rothschild, I am able to give a figure (Pl. XV.) of the var. *molleri* from a sketch made for him by Mr. J. Green, from a female specimen in his possession exhibited a few years ago in the Zoological Gardens.

I have myself examined two fresh specimens of this variety from Lisbon, one alive, received from Sr. F. Mattozo Santos, Director of the Museum Bocage at Lisbon. In the live specimen the crimson-red colour was distributed over the parotoids, the upper eyelids, the throat, the spots at the angle of the mouth and on the sides, and the spot on the forearm and thigh. On the back and tail there was no red colour, but many of the yellow spots were partly bordered or as if washed over in the centre with a dirty grey. In the second specimen the red colour was restricted to the parotoids, the upper eyelids, and the spot at the angle of the mouth. The markings of the back, limbs, tail, sides, throat, and belly being mostly light grey in the centre and on the borders.

On careful examination of the red and grey markings in these specimens, I have come to the conclusion that these are due, not to special pigments in addition to or in combination with the

yellow, as has been supposed, but to the absence of pigment, the pigmentless flesh, highly flushed with blood, being exposed on certain patches and the grey colour resulting from the absence of yellow combined with a small quantity of black pigment.

The largest specimen of the var. *molleri* examined by me measures 109 mm. to the posterior extremity of the vent, the tail measuring 73.

III. VAR. *TÆNIATA*.

This variety differs from the typical form in the arrangement of the dorsal spots, which are regularly disposed in two parallel series continuous with the patches on the parotoids, and not unfrequently form two uninterrupted stripes. Even when the two stripes are broken up into as many as 12 spots, these still retain their duplex disposition, not encroaching over the black vertebral line (Area A), or if they do so, as is rarely the case, only on the nape and the posterior end of the body, where they may be connected in **H**-like fashion by a cross-bar. Although in this variety the black often predominates over the yellow, it is not uncommon to find specimens in which the reverse takes place. In cases where the yellow has so far invaded the upper surface as to actually constitute the ground-colour, the black vertebral stripe may be reduced to a mere series of spots, and Werner (31, p. 155, pl. vii. fig. 23) even mentions and figures one in which the black is completely absent from the back. The upper eyelid and the parotoid gland are entirely yellow (the yellow patch on the latter rarely broken up), the two spots nearly always running together and often also confluent with the markings on the back, which is rarely the case with the typical form. The sides are usually devoid of markings, and if present they only occur in small numbers. Yellow markings are usually present on the snout, which is but exceptionally the case with the typical form. The spot situated at the angle of the mouth is absent in about 35 per cent. of the specimens. Gular region and lower surface of body with a varying amount of yellow, sometimes entirely yellow with a black spot or bar on the gular fold; the markings have often a tendency to dispose themselves in longitudinal series, thus the belly may be black with a yellow lateral stripe or yellow with one or two black stripes in the middle. Limbs with the black usually predominating; a characteristic yellow blotch near the base of the arm and thigh, and a second on the forearm and leg being constant, and usually larger than in the typical form. Hand and foot mostly black and yellow, the yellow patches being nearly always confluent with those on the forearm and leg. Nearly entirely yellow specimens have likewise yellow limbs with merely 2 or 3 black spots or cross-bars. As on the limbs, the yellow may predominate over the black on the tail and frequently extend to the lower surface, which is rarely the case in the typical form. The two yellow dorsal bands often fuse on the upper surface of the tail.

The colour varies from sulphur- or lemon-yellow to a deep orange.

Some specimens with the markings almost vermilion-red, instead of yellow or orange, obtained by Fr. v. Schweizerbath near Stuttgart, are regarded by her as a distinct variety and named var. *coccinea* (28), but this is clearly to be regarded as a merely individual peculiarity, not deserving of a varietal name, and the figure given by her corresponds, but for the colours of the markings, with the var. *teniata*, the prevalent form round Stuttgart. Considering that the bright markings may vary, in the same locality, from chrome-yellow to a deep orange, the so-called var. *coccinea* represents merely an intensification of a tendency existing in German specimens. Fr. v. Schweizerbath has been informed by Prof. E. Haeckel that such a Salamander was found by him many years ago in the Saal Valley, near Ziegenrück, and it is not unlikely that vermilion-spotted specimens will be discovered in other parts of the habitat of the var. *teniata*. My father was informed by an intelligent peasant woman in Belgium that on the occasion of her witnessing, in a wood, just before a thunderstorm, a sudden apparition of Salamanders in huge numbers, some among them were distinguished by being marked with red instead of yellow. In D'Orbigny's 'Dictionnaire d'Histoire Naturelle' (7, p. 307) allusion is made to a specimen found near Bordeaux, which must have been similar to the one described by Fr. v. Schweizerbath. In Belgium, the markings are of a more or less bright yellow but not orange, and in most cases they form interrupted stripes. In Brittany the markings vary from sulphur- to chrome-yellow. Out of 50 specimens obtained together, within a space of one hundred square yards, last summer at Roscoff, about half had the stripes uninterrupted but varying much in width. M. Ghidini, of the Geneva Museum, having had occasion to examine 500 specimens received alive from Stadtoldendorf in Brunswick, found that about 400 had the two parallel stripes uninterrupted, or nearly so, 50 had them much broken up, whilst the remaining 50 were nearly entirely yellow, with the black reduced to spots or narrow stripes. The specimens from the Harz and neighbouring hills, of which I have seen many, vary in the colour of the markings from chrome-yellow to a rather deep orange.

A male specimen from the Harz, in which the yellow colour prevails, is represented on Plate XV.

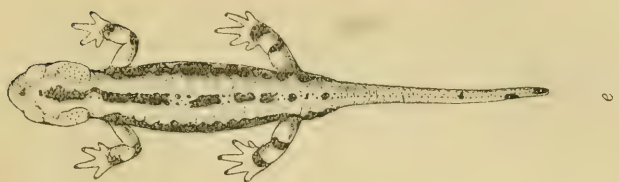
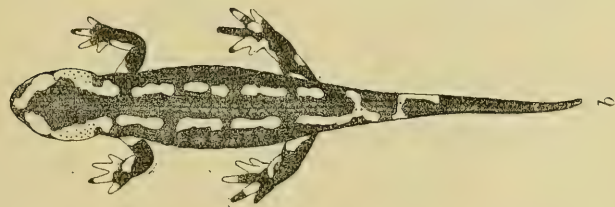
Figures of the var. *teniata* are given by Wurfbaïn (33), Gesner (13, ii. p. 80), Perrault (21, pl. 16. p. 77), Duvernoy (11, pl. xl. fig. 1), Mme. Phisalix (22, pl. i.), and Dürigen (10, p. 577). The descriptions of Leydig (19), Lataste (16), and Martin and Rollinat (20) are also applicable to it, as well as the var. B of Duméril and Bibron (9) and the vars. *f* to *k* of Schreiber (27).

Five specimens are represented in text-fig. 102, to give some idea of the variations in the markings:—

a, from the Harz, is exceptional in having the spots much reduced in size; spots on the belly numerous, moderately large and roundish.

b, from Maredsous, Belgium, represents the condition most

Text-fig. 102.



THE SPOTTED SALAMANDER. Var. *teniata*.

frequently met with in France, Belgium, and Germany; the ventral spots are confluent into a broad band on each side.

c, from Roscoff, Brittany, is selected out of fifty specimens as having the spots confluent into two stripes, and yet

II. Var. *teniata*.

SEX.	LENGTH	SECTION				AREA					D.	G.	V.	
		I.	II.	III.	IV.	C.	B.	A.	B.	C.				
1. ♂	92	1.2	1.23	2.45	2.5	—	2	—	1.3.4.5	—	0-0	+	+	+
2. ♀	104	1.2	1.2	1.2	1.2	—	2	—	1	—	0-0	+	+	+
3. ♀	107	1.2	1.2	1.2	1.2	—	2	—	1	—	0-0	+	+	+
4. ♀	108	1.2	1.23.4	3.4.5	3.6	—	2.3.6	—	1.4	5	0-0	+	+	+
5. ♀	94	1.2	1.2	2.3	2.4.5	—	2	—	1.3.4.5	—	0-0	+	+	+
6. ♀	107	1.2	1.2	1.3	1.3	—	2.3	—	1	—	0-0	+	+	+
7. ♀	80	1.2	1.23	2.3.4	2.4	—	2	—	1.3.4	—	0-0	+	+	+
8. ♀	102	1-4	3.4.5.6	5-9	10.11	—	1.2.3.5.8.11	—	4.6.7.9.10	—	0-0	+	+	+
9. ♀	82	1-3	3.4.5.6	6.7.8	9.10	—	2.4.7.9	—	1.3.5.6.8.10	—	0-0	+	+	+
10. ♀	100	1.2	1.23	2.3.4	3.5	4	2.4	—	1.3.5	—	0-0	+	+	+
11. ♀	97	1.23	2.3.4	3.5	6.7.8	—	1.3.8	—	2.4.5.6.7	—	0-0	+	+	+
12. ♀	97	1.2	3.4.5	4.5.6.7	8.9	—	2.3.5.7.9	—	1.4.6.8	—	1-4	+	+	+
13. ♀	74	1	2.3.4.5	6.7	8.9	3	1.3.5.6.9	1*	1.2.4.7.8	—	2-1	+	+	+
14. ♂	95	1	1	1	1	—	1	1†	1	—	Completely yellow, confluent with belly	+	+	+
15. ♂	94	1	1	1	1	—	1	1*	1	1	0-0	+	+	+
16. ♂	91	1.2	1.2	1.2	1.2	2	2	—	1	1	0-0	+	+	+
17. ♂	80	1.2	1.2	1.23	3.4	—	2.4	4	1.3	4	1-1	+	+	+
18. ♂	95	1.23	2.3	2.3.4	3.4	—	2.4	—	1.3	—	1-0	+	+	+
19. ♂	85	1.23	2.3	3.4	3.4	—	2.4	—	1.3	—	0-0	+	+	+
20. ♂	104	1-4	4.5.6	5.6.7	5.7.8	—	2.4.6.7.8	—	1.3.5	—	0-0	+	+	+
21. ♀	102	1.2	1.23	2.3.4.5.6	5.6.7	4	2.5	—	1.3.6.7	—	0-0	+	+	+
22. ♀	93	1.2	2.3	3.4.5.6	6.7	—	2.4.6	—	1.3.5.7	—	0-0	+	+	+
23. ♀	91	1.23	2.4	5.6	7.8	—	1.3.4.5.7	—	2.6.8	—	1-1	+	+	+
24. ♀	78	1.2	1.23	1.3.4	3.4.5	—	1.4.5	—	2.3	—	0-0	+	+	+
25. ♀	57	1.2	1.3	3.4.5.6	7	—	2.3.6.7	7	1.4.5.7	—	0-0	+	+	+
26. ♂	102	1.2	1.2	1.2	1.2	—	2	—	1	—	0-0	+	+	+
27. ♂	86	1.2	1.2	2.3	2.3.4	—	2.4	—	1.3	—	0-0	+	+	+

* Spot No. 1 forms the letter H in Area I.

† Head and body nearly entirely yellow, the black reduced to an interrupted stripe along the vertebral line, and a lateral band along Area C.

- | | | |
|-------------------------------|-----------------------|---------------------------------|
| 1. St. Malo. | 9. Waulsort, Belgium. | 20-23. Langenbruck, Swiss Jura. |
| 2-3. Roscoff. | 10-17. Harz. | 24-25. Oporto. |
| 4. Armainvilliers near Paris. | 18-19. Lippe Detmold. | 26-27. Portugal. |
| 5. Beure, near Besançon. | | |

much reduced in width; the small amount of yellow on the parotoids is also very exceptional; the belly is entirely black.

d, also from Roscoff, is remarkable for the regularity of the two yellow dorsal bands; the yellow predominates on the lower parts.

e is selected out of many from the Harz as showing the preponderance of yellow, the black of the upper surface being reduced to a few markings; the throat and belly are yellow with scanty black spots.

Leaving out the specimen from Rome mentioned by Duméril (possibly through some error of locality), the habitat of this variety is restricted to France, Spain and Portugal, Belgium, S. Holland, Germany, and Switzerland. On its occurrence alongside with the typical form, see above, p. 333.

IV. DR. KAMMERER ON THE VARIATIONS OF *SALAMANDRA MACULOSA*.

In the introduction to this paper I have expressed surprise at the distinction between the typical form and the striped form not having been brought out more clearly by the authors who have dealt with the varieties of this species.

This applies also to the most recent worker on the subject, Dr. Kammerer (14, p. 69), some of whose highly interesting observations are here reproduced. As he has accompanied them with remarks on the correlation between the coloration and the conditions under which the individuals occur and has drawn provisional conclusions with which I cannot always concur, I have appended my criticisms, inserted in square brackets.

It is possible, he thinks, to establish the existence of local modifications as concerns the intensity of the yellow and its distribution on the black ground-colour. Number, size, and intensity of the yellow spots are in direct proportion to one another. One seldom meets with specimens with few but large spots*.

[This statement is evidently meant to apply to the typical form with isolated spots, but fails to express the state of things in cases when several spots fuse together and are consequently large and few; the very yellow specimens, which are not so very unfrequent, having the spots few in number.]

The contrary, many but small spots, occurs only in the var. *corsica* (*fide* Bedriaga)†.

[This is perfectly true as regards Bedriaga's specimen from

* "Es lassen sich nämlich hinsichtlich der Sättigung des Gelb und der Vertheilung desselben auf der schwarzen Grundfarbe lokale Abänderungen feststellen, die durch eine Menge verschiedenartiger Faktoren beeinflusst zu sein scheinen. Zahl, Grösse und Sättigung der gelben Flecken stehen in direkter Proportionalität zu einander: man findet selten Individuen mit wenigen, aber grossen Flecken."

† "Das Umgekehrte, viele, aber kleine Flecken, tritt nur bei der var. *corsica* Savi (vgl. v. Bedriaga) auf."

Bocognano (now in the British Museum), but we must remember that such a correlation is by no means constant in Corsica, for the figure of the type of *S. corsica*, in Bonaparte's 'Fauna Italica' shows the number of spots not to be in excess of that of a typical specimen from Italy, figured in the same work. The spots on the Bocognano specimen, although more numerous, are not smaller than is usual in specimens from Hungary, Bosnia, Roumania, &c., or, for instance, the one from Italy, so beautifully figured by Rusconi. It is also to be borne in mind that Savi in his original description of *S. corsica* ascribes to it fewer spots than to *S. maculosa*.]

Where there is much yellow this is usually also strongly intensified (dark straw- or orange-yellow), whilst scanty yellow is, apart from rare exceptions, pale (pale sulphur or lemon)*.

[I cannot agree in the least with this statement, as out of over 50 specimens from the Harz Mts. which were recently received at the Zoological Gardens, those in which the yellow constituted the ground-colour were, as a rule, of a paler yellow than those in which the black predominated. Again, in some specimens from Dresden, as my father informs me, and in others from the Harz, with the spots few and of small size, the colour was decidedly orange, whilst in specimens from Brittany and Belgium with much yellow, the latter varied from pale lemon to chrome. A large number of specimens received alive from Hungary (N. Beeskeret), mostly with small, or very small spots, few in number, had these orange, not yellow.]

The author then enumerates, with reference to his own material and some indications in the literature, the local differences in connection with the geographical distribution:—

1. In specimens from the hilly districts (Riva, Tyrol, 70–120 m., Schandau on Elbe, Saxony, 130 m.), and in those from the North-German plain (Minden in Prussia, 50 m.) and from the South of France and Spain (*vide* Bedriaga), the yellow is distributed in great profusion, the spots of the upper surface being often confluent into broad longitudinal bands, or even becomes the predominant colour, and in the S. French and Spanish Salamanders the dark ground-colour disappears almost entirely. Besides, the under surface of such specimens is strongly spotted or even entirely yellow.

2. In specimens from Portugal (var. *molleri* Bedriaga) red spots formed of a special pigment appear in addition to the mostly numerous yellow spots, which here also invade the ground-colour.

3. The same remarkable appearance obtains likewise in many specimens from the neighbourhood of Vienna (Hütteldorf, Mödling, Puckersdorf, Hadersdorf, Unter-Tullnerbach), in which

* "Wo viel Gelb vorhanden ist, da ist es gewöhnlich auch stark gesättigt (Dunkelstroh oder Orangegelb), während spärliches Gelb, von seltenen Ausnahmen abgesehen, blass (Lichtschwefel oder Citrongelb) aussieht. Bei einer mässigen Quantität Gelb treten die Flecken bald in dunkleren, bald in helleren Schattierungen auf, jedoch in der Regel nicht bei ein und demselben, sondern bei verschiedenen Exemplaren."

red of different shades (brownish red, greyish red, claret-red, blood-red, vermillion, brick-red) is present, namely on the parotoids, on the forehead and vertex, round the eyes, at the angle of the mouth, on the throat, and occasionally also over the whole body. Otherwise the Vienna individuals are mostly provided with moderately large and moderately numerous spots, the intensity of the shade of which varies to the extent that in different examples from one and the same locality they may be pale or deep yellow.

4. Specimens from the Central Mountains of Germany, the spurs and the lower region of the Alps (Salzburg, 450-638 m., Kaumberg, Lower Austria, 490 m., Meran, Tyrol, 350 m., Villach, Carinthia, 500-600 m., Jenbach, Tyrol, 530 m., Wochein Valley, Carniola, 510 m., Bozen, Tyrol, 250-300 m., Kapfenberg, Upper Styria, 500 m., Wiesing, Bavaria, 750 m., Mondsee, Upper Austria, 480 m., Kufstein, N. Tyrol, 490 m.) show an average condition, *i. e.*, the mostly irregularly formed and distributed spots on the upper surface being moderately large and numerous, those on the lower surface being scanty and pale; all sorts of shades of yellow are observable in different individuals.

5. In specimens from the Alpine region, from the upper limits of the vertical range of the species (Salzburg, 1000 m., Bozen, Tyrol, 920 m., Appenzell, Switzerland, over 1000 m.), the black ground-colour predominates, the yellow spots being small, few, and very pale. The lower surface is usually unspotted. According to Walter Bendt, of Gratz, a specimen obtained on the Schöckl Plateau at an altitude of about 1230 m. (highest altitude on record) had only a few spots which were not of a well-defined yellow, but more brownish.

6. Small number and size of spots are also shown by specimens from S.E. Europe, viz., from Orsova (*vide* Mojsisovics), Montenegro (*vide* Werner), and Athens (*vide* Werner), and generally by Turkish and Greek Salamanders, also by the specimens from the extreme south of the distribution (Haifa, Syria, and var. *algira*).

Not everywhere are the local variations quite constant, viz., there occur in the Alpine region (Alpine valleys up to 600 m., *vide* Werner) rather strongly and largely spotted specimens, whilst in the neighbourhood of Vienna, among an average of strongly spotted specimens, there are also some, if only a few, with small and yellow spots. Indications of red spots on the parotoids, on the inner edge of the upper eyelids, as well as between the angle of the mouth and the lower border of the eye, are also to be found in isolated specimens from Lower Styria and the Bavarian Alps.

An absolute constancy with regard to the multiplicity of the factors which influence the markings, many of which may, of course, counteract one another in the same locality, cannot be expected.

A precise test of the geological, climatic, and meteorological

conditions of the localities of a great number of specimens has shown that the colour-variations can be grouped on a geographical basis* :—

1. A warm climate increases, a cold climate attenuates the markings and their intensity.

[Salamanders from Belgium and the Harz district, with cold climates, in the north of the distribution of the species, have on an average large markings, the Harz specimens in particular being often bright yellow or orange, whilst specimens from S.E. Europe, N. Italy, to say nothing of extreme southern specimens (Syria and Algeria), to which Kammerer himself alludes, have, as a general rule, small and few spots. Specimens from the hilly parts of Belgium, from most French localities, either at sea-level (Boulogne, Brittany, Bordeaux) or at a considerable altitude (Eaux-bonnes, Pyrenees, 750 m.), are absolutely identical in the general style of markings and in their colour, thus showing that climate has no bearing on this character.]

2. Localities with very damp air and soil, provided in addition with a great number of water-courses, favour the number, size, and intensity of the yellow spots, whilst conversely dryness and scarcity of water-courses produce a decrease in these respects.

[One does not well conceive the Salamander flourishing under other conditions than the first. It is difficult to believe that the Salamanders with much yellow, such as we have from Bordeaux, S. Italy, and Asia Minor, are from damper localities than those with small spots from Austria, Hungary, and Roumania. What I have said above of the Salamanders of France is against Dr. Kammerer's contention.]

3. In localities where the sub-soil consists of schists, igneous rock, and sandstone, Salamanders are as a rule more numerous, larger, and more intensively yellow-spotted than in calcareous hills, where they are not found in such abundance; possibly this may bring us back to proposition 2, calcareous hills being always

* "Eine genaue Prüfung der geologischen, klimatischen und meteorologischen Verhältnisse möglichst vieler mir aus eigener Erfahrung und aus Museen durch Belegexemplare, sowie aus der Litteratur durch Beschreibungen der betreffenden Exemplare bekannt gewordenen Fundorte hat ergeben, dass die Farbenabänderungen an Stelle der geographischen Gruppierung auch in folgender Weise geordnet werden können:

1. Warmes Klima unterstützt, kaltes Klima unterdrückt die Fleckenzeichnung und deren Sättigung.

2. Gegenden mit starker Luft- und Bodenfeuchtigkeit welche womöglich ausserdem reich an kleinen Wasserläufen sind, begünstigen Zahl, Grösse und Sättigung der gelben Flecken, wogegen Trockenheit und Armuth an Gewässern dieselben zurücktreten lässt.

3. In Gegenden, wo Schiefer, Urgestein und Sandstein den Untergrund bilden, sind die Salamander in der Regel zahlreicher, grosser und intensiver gelb gefleckt als im Kalkgebirge, wo sie überhaupt nicht so häufig zu finden sind. Möglicher Weise lässt sich dies auf Punkt 2 zurück führen, indem das Kalkgebirge stets trockener und ärmer an Gewässern ist, als das aus den übrigen genannten Gesteinsarten sich zusammensetzende Gebirge.

4. Ein ganz besonderes Überhandnehmen der gelben Farbe und deren Sättigung, sowie das Auftreten von rothen Flecken, findet auf Lehm Boden statt, wogegen auf schwarzen Humus das Umgekehrte obwaltet."

drier and poorer in water-courses than those formed of the other mentioned rocks.

[I am not sufficiently acquainted with the formations on which the specimens in the museum were obtained to fully discuss this proposition, but I wish to observe, on the testimony of my father, who has examined large numbers of specimens from Belgium, found on Carboniferous and Devonian limestone, and from Brittany, on granite, that Salamanders from these places agree absolutely in the extent of the spots and in the comparatively pale colour of the same as well as in size. This is true also of the Salamanders found over the greater part of France (var. *teniata*, with markings hardly ever orange), and yet the localities about which we have definite information are on the most different geological formations:—*a.* Ambleteuse, near Boulogne (Kimmeridge and Upper Oolite, clay with lime); *b, c.* St. Malo and Roscoff (Granite); *d.* Bordeaux (Pliocene and Oligocene clays); *e.* Marly, near Paris (Oligocene limestone); *f.* Eaux-bonnes, Pyrenees (Cretaceous limestone). This list clearly indicates that, in France at any rate, the subsoil has nothing to do with the coloration of Salamanders.]

4. A quite special increase of yellow colour and its intensity, as well as appearance of red spots, takes place on a clay soil, while, on the other hand, the reverse takes place on black humus.

Dr. Kammerer concludes by observing that the above correlations are subject to many irregularities, and that he would formulate them with reserve, were it not a fact that these irregularities or apparent exceptions are almost invariably to be satisfactorily explained by the simultaneous occurrence of opposed factors in one and the same locality (*e. g.*, water poverty but clay soil, or warm climate but calcareous hills, &c.) and that it is therefore necessary to make a complete investigation of the physical conditions of each separate locality.

[Suffice it to add once more that the large Belgian Salamander, copiously marked with yellow, occurs in great abundance in places offering a combination of the two principal factors which, according to Kammerer, would produce small size and scarcity of markings, viz., a dark soil rich in lime and a cold climate.

It is also important to observe that, contrary to Kammerer's results, our blackest specimen of the typical form is from a hot locality (Ticino) at an altitude of only about 600 metres, our yellowest from the highest altitude on record, 1600 metres (Calabria). It might be objected that in the case of the latter the altitude is compensated by the latitude, but that will not answer, since at a more southern latitude, and almost at sea-level, on the north coast of Africa, paucity of yellow markings is the rule. In the var. *teniata*, a totally black specimen has been recorded from the Siebengebirge (Rhenish Prussia), whilst the opposite extreme of almost wholly yellow specimens is on record from as distant and dissimilar localities as the Harz, Bilbao, Toulouse, and (?) Rome.]

Since the publication of the above conclusions, Dr. Kammerer has instituted a series of experiments with the object of showing that the colour and dampness of the soil has an influence on the increase or reduction of the yellow markings, and the results of some of the experiments have been recently published, with figures, in the German paper 'Natur' (15).

In view of the geographical distribution of the typical form and the var. *tæniata*, which I have endeavoured to trace from a large material, Dr. Kammerer's results are surprising, for the pictures given by him show the offspring of a female of the typical form, presumably from Austria, to belong to the var. *tæniata*. Considering the enormous number of specimens of the two forms which he has kept in his terrarium, is the possibility excluded of some confusion having taken place? Or may not the male have belonged to the latter variety, and have transmitted his characters to the offspring? Then, again, as to the changes in markings taking place in the same individual in the course of growth, may not some error of identification have crept in? After the study I have made of the disposition of the markings, I can hardly refrain from expressing a doubt as to the middle specimen of the left-hand lower series on fig. 1 being the same as the one to its right, for it will be observed that the two yellow stripes or series of spots are much more distant from each other in the younger stage than in the older, and this is a change difficult to conceive to have taken place in one and the same individual. In fact, were it not for the statement of so high an authority as Dr. Kammerer, whose experiments appear to have been conducted with so much skill, care, and patience, I think I would not have hesitated in pronouncing the two figures in question to have been taken from different individuals.

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EXPLANATION OF PLATE XV.

Salamandra maculosa.—Forma *typica*, ♂, from Lugano: var. *molleri*, ♀, from Portugal; var. *teniata*, ♂, from the Harz.

17. On the Mountain Nyala, *Tragelaphus buxtoni*.*

By R. LYDEKKER.

[Received December 1, 1910: Read February 21, 1911.]

(Plate XVI.† and Text-figure 103.)

About the 10th of September I received a communication from Mr. Rowland Ward to the effect that the skin, skull, and horns of an apparently new Kudu-like Antelope had been received at his establishment in Piccadilly from Mr. Ivor Buxton, by whom the animal had been shot in Abyssinia. An inspection of the specimen a few days later fully convinced me of the correctness of Mr. Ward's diagnosis; and I accordingly wrote a letter to the 'Times,' which duly appeared in that journal on September 23rd, 1910, under the heading of "A New African Antelope." In that letter it was stated that the specimen had been killed on the Arusi plateau of Gallaland, in Southern Abyssinia, at an estimated height of about 9000 feet above sea-level, and that it apparently indicated a new species of Antelope in some degree intermediate between the Nyala (*Tragelaphus angasi*) and the Kudu (*Strepsiceros capensis*), but rather nearer to the latter than to the former. In conclusion, it was urged that the specimen ought to find a permanent home in the British Museum. It was also suggested that the species might be known as the Spotted Kudu.

Shortly after the appearance of this letter, Mr. Buxton wrote to say that he would be pleased to present the specimen to the Museum, and likewise giving full and more precise information with regard to the locality where it was obtained. The matter having thus become public, I decided that the time had come to give the animal a scientific name; and *Strepsiceros buxtoni* was accordingly proposed by myself in 'Nature,' vol. 84, p. 397, 1910. It was, however, added that it might be deemed advisable to merge the genus *Strepsiceros* in *Tragelaphus*, in which event the title of the new species would be *Tragelaphus buxtoni*. As to locality, Mr. Buxton, after reference to his note-book, informed me that the type specimen of the new Antelope was obtained during the summer of 1910, to the west of the Arusi plateau of Gallaland, in the Sahatu Mountains, at an estimated elevation of 9000 feet; these mountains being situated some distance to the south-east of Lake Zwi (Zuay). The ground on which the animal was killed—as I gather from a photograph taken by Mr. M. C. Allbright, who accompanied Mr. Buxton on his trip—is of an open and stony nature, with scattered dwarf bushes and tussocks of grass.

Soon after the publication of the aforesaid notice in 'Nature' I learned that Mr. Buxton had brought home the head-skin

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† For explanation of the Plate see p. 353.



H. Goodchild, del et lith.

A. S. Huth, imp.

THE MOUNTAIN NYALA.
TRAGELAPHUS BUXTONI.

and skull of a second male of the same species, and also the skulls and horns of two other, and apparently younger, individuals of this sex—all being members of the herd from which the type specimen was obtained. Nor is this all the available material; for Mr. Allbright had likewise shot a fine old buck out of the same herd, of which the skull and skin were brought home, the head being mounted and the body-skin preserved flat. All these specimens, thanks to the courtesy of their respective owners, I have had full opportunities of examining. It should be added that, according to Mr. Buxton, the females of the new species are coloured like the males and are devoid of horns.

The second head brought home by Mr. Buxton and the complete skin belonging to his companion represent darker-coloured and apparently older bucks than the type; and after seeing these specimens I came to the conclusion that the Sahatu Antelope is nearer to the Nyala than to the Kudus. This opinion is recorded in the 'Field' of October 22nd, 1910 (vol. 116, p. 798), where I definitely stated that the species ought to be known as *Tragelaphus buxtoni*. Finally, in the recently published sixth edition of Mr. Rowland Ward's 'Records of Great Game' I have suggested the name Mountain Nyala as the popular designation of the species.

That the type specimen, which is a male, and stands, as mounted, 4 feet 4½ inches at the withers, represents an Antelope belonging to the Kudu and Bushbuck group is self-evident, and further words on this subject are therefore superfluous. Kudus and Bushbucks are admittedly near relatives; and the main distinction between the two is to be found in the characters of the horns. In adult bucks of both species of Kudu the hind surface of the basal portion of the horns is rounded and devoid of an external ascending keel, although there is a well-marked front or inner keel. The horns of Bushbucks, on the other hand, have a pronounced keel at the back of the basal portion, in addition to which is a distinct front keel; and, in consequence, the surface between these two keels is flat, instead of round. This flattened intercarinal surface is, in fact, continued nearly to the summit of the horn, forming a spiral round the axis. In adult Kudus a second keel is developed higher up on the horns, and such a flattened surface consequently exists only near the tip. In the horns of a young Kudu, on the other hand, there is a second keel; and it follows that the horns of the adult may be compared to Nyala horns with an additional basal portion devoid of a second keel. This shows that the distinction between *Strepsiceros* and *Tragelaphus* is very slight indeed.

Kudu-horns are, however, distinguished from those of the Bushbuck group by their open, corkscrew-like spiral of three complete turns, those of Bushbucks never having more than a couple of such turns.

In Kudus the males and females are alike in colour, or nearly so, the coloration on the body consisting of vertical white stripes,

with a tendency to spotting on the hind part of the flanks of the smaller species. Both species have a mane and dorsal crest, at least in the males; but while the larger kind has none, the Lesser Kudu carries one white gorget on the throat and another on the chest. The tail is of moderate length and not very bushy.

In the Bushbuck group the females are frequently—although by no means invariably—brighter coloured and more profusely striped and spotted than the males; the markings on the body, when fully developed, comprising both stripes and spots. The males, at any rate, have a dorsal crest; and there are often two gorgets on the throat and chest, although these are reduced to one in the Nyala. The tail is in most cases relatively long and more bushy than in Kudus.

The conformation of the horns affiliates Mr. Buxton's Antelope to the Bushbuck group (*Tragelaphus**), from all the other members of which it is distinguished by its superior size. From the Nyala, which makes the nearest approach in this respect, *Tragelaphus buxtoni* differs in the (reported) identity of the colour in the two sexes, in the shorter coat and less bushy tail of the male, the presence of two white gorgets on the throat and chest, the absence of any marked difference in the general colour of the lower part of the legs from that of the body, and also in the more open spiral formed by the more massive horns.

In the type specimen (Pl. XVI.), which, as already mentioned, is an approximately full-grown but young buck, the horns form about one complete turn, and have the general characters of those of the Nyala, although relatively heavier, and diverging much more outwardly, with a very open spiral. They are obliquely ridged at the base, and the long smooth terminal portion is worn yellow at the tip. The length along the outer curve is 37 inches, the basal girth $9\frac{1}{4}$ inches, and the tip-to-tip interval 21 inches.

The coat is rather long and coarse, its general colour being speckled brown-fawn, passing into dull tan on the sides of the face, and becoming darker on the front surface of the muzzle, and chocolate-brown on the forehead above the white chevron, which is not very conspicuous. The under-parts are lighter, but on the front of the fore-legs and the lower part of the hind pair the tuft becomes considerably darker. There is a short dark brown mane on the neck, continued backwards as a mingled brown and white dorsal crest. The bushy tail is white beneath. The ears, which are much of the same type as those of the Nyala, are of moderate width, bluntly pointed at the tip, and tubular for a considerable distance at the base; most of the long hairs on the inner edges being white, as is also much of the inner surface of the outer margin.

The white markings include a not very distinct chevron between the eyes, the usual patches on the sides of the muzzle and chin, a pair of spots on each side of the face below the eye, and a smaller

* *Linnotragus* I regard as a subgenus.

Text-fig. 103.



Head of an old Buck of the Mountain Nyala belonging to Mr. Allbright, from a photograph supplied by Mr. Rowland Ward.

and fainter one behind the same, a narrow but deep gorget on the throat, and a much wider but less deep one of a more lunate shape on the upper part of the chest. A curved row of nine spots—some of which are much fainter than the rest—extends from a point about over the head of the thigh-bone to the back of the lower part of the shoulder. There is another white spot on each side of the buttocks. The inner surface of the thighs and of the upper portion of the fore-legs is dirty white. A white area occupies the back of each fore-leg below the knee, extending on to the outer and inner surfaces of the limb, but not reaching the pastern; and a somewhat similar area occurs on the hind-leg, extending slightly above the hock. There is a pair of white oval spots on each fetlock some distance above the hoof.

The second head obtained by Mr. Buxton is that of a much older buck, as is attested by the horns, which have closely approximated rings at the base, are of greater length, and are much battered on the front surface, and worn away at the tips, of which the left one is broken. They form about one turn and a quarter, and have a more upright direction than in the type specimen; in both of which respects they are more Nyala-like. Although the buck to which this head belonged was a member of the same herd as the type, the coat is considerably longer and looser, especially on the throat, where it forms an incipient fringe. The colour is also darker and greyer, being a greyish brown, comparable to that of a Waterbuck. The face is likewise distinctly darker, the whole of the lower portion being of a chocolate-brown like that of the forehead, and the tan restricted to the area round the eye, behind which is a small white patch. There is a tendency to rufous in the hair round the muzzle, and also in that between the horns. In consequence of the darker colour of the rest of the face, the white frontal chevron is much more conspicuous than in the type specimen. The upper throat-patch or gorget is also very conspicuous, and is continued by means of scattered white hairs almost to the lower gorget.

The mounted head belonging to Mr. Allbright (text-fig. 103) is likewise that of an old buck, and agrees in essential characters with the one last-mentioned. The body-skin of the same animal differs from that of the type not only in its longer and darker hair and the greater development of the dorsal crest, but likewise in the presence of two indistinct vertical white stripes—one considerably longer than the other—on the hind-quarters, with faint traces of a still shorter third one. In this respect the specimen makes a further approximation to the Nyala.

The skull is not yet cleaned, but does not apparently present any very distinctive features of generic importance. It is true that the base of the horn-cores lacks the pronounced front keel found in the Kudu, but as this keel is also lacking in the Lesser Kudu, it cannot be regarded as a feature of much importance.

On the whole, the Mountain Nyala seems to come nearest to the species from which it takes its name, although in the general

form of the head and the character of the tail it is distinctly Kudu-like.

In conclusion, I may reiterate my opinion that *Tragelaphus burtoni* tends to connect the Bushbuck group so closely with the Kudus as to render the generic separation of the latter from *Tragelaphus* (in which, as already stated, I include *Limnotragus* as a subgenus) inadvisable.

EXPLANATION OF PLATE XVI.

The type specimen, a subadult buck, of the Mountain Nyala,
Tragelaphus burtoni.

18. Observations on different Gibbons of the Genus *Hylobates* now or recently living in the Society's Gardens, and on *Symphalangus syndactylus*, with Notes on Skins in the Natural History Museum, S. Kensington. By Dr. F. D. WELCH, F.Z.S.

[Received November 29, 1910: Read February 21, 1911.]

Very few specimens of the genus *Hylobates* arrive in good health in England or live for more than a few months, but during the last five years the Society has exhibited examples of different species, of which the following are now living in the Gardens:—A male of the rare *H. hainanus* from Hainan, which arrived in December, 1907; a male *H. leuciscus* from Borneo, which arrived in May 1908; and a female *H. agilis* from Sumatra, which arrived in December 1905. In addition to these an adult male *Symphalangus syndactylus* in good health arrived on October 26, 1910, and is the finest specimen the Society has yet received. As some external characters and the coloration and voice can be studied only in living specimens, some observations I have made on these genera may be worth recording.

In the genus *Hylobates*, from observations taken at intervals on four males living in the Gardens, I am strongly of the opinion that the development of certain parts of the external genital organs is delayed to a later period of life than is the case in *Anthropopithecus* and Man, and, so far as I can discover, no notes have been published on this subject. My attention was first drawn to the subject by Mansbridge, keeper of the Society's Apes, but I have not accepted any information from him until I have confirmed it myself, and I am well aware that several mistakes have previously been made about the sex of *Hylobates* on account of the large clitoris being mistaken for the penis (see Pocock, P. Z. S. 1905, vol. ii. p. 169). I have made a careful examination of all the specimens, and am certain that the sex is as I have stated.

The male *H. hainanus* has altered greatly in the external

genital organs. On arrival in December 1907 it was in good health and measured about 14 inches from crown to ischial callosities, and there were then no signs of a scrotal bag, the skin between penis and ischial callosities being quite flat. About the end of March 1909 a scrotal bag gradually formed, and by the first week in July 1909 this could be seen quite easily when the animal was at the opposite side of the cage with its hind legs separated. The scrotal bag had then reached its present size and appearance, being just over an inch long with a broad base and tapering rapidly towards a point, thickly covered all over with short black hair, and placed well above and in front of the anterior ends of the ischial callosities, there being a space over half an inch between the callosities and its posterior surface. The scrotal bag is not at all pendulous, and the long axis runs downwards and forwards. At that time, July 1909, the animal's height, measured against the bars when sitting, was 16 inches. It was impossible to measure this male out of the cage or to handle it, and as all *Hylobates* specimens stoop when sitting, the real height of the animal when hanging at full length was probably about 1 inch more than this. The measurement against the bars was repeatedly taken to ensure accuracy. Only one male *H. hainanus* has been exhibited in the Gardens before, a younger animal, to the skin of which, now in the Natural History Museum, I shall refer later.

Retention of the testicles, either within the abdominal cavity or in the inguinal canal, is a common human abnormality. One or both testicles may be thus retained, and in some cases they descend, later in life, into the scrotal bag. I certainly do not think that this male *H. hainanus* was abnormal, but that the absence of a scrotal bag before March 1909 was the normal condition in the genus and species, and my reasons for this opinion are as follows:—

The male *H. leuciscus* from Borneo, now in the Gardens, had on arrival no scrotal bag, and in December 1909 I made a careful digital examination of the external genital organs. The skin between the penis and ischial callosities was slightly wrinkled, but would not stretch when pulled, and did not hang down when the animal was standing erect. There was nothing to be felt under the skin between penis and callosities which I could say with perfect certainty were the testicles, and consequently these organs must be exceedingly small in proportion to the size of the animal. This *H. leuciscus* was in good health on arrival and has continued so, and at the present time (November 1910) there is no sign of a scrotal bag. The animal at present measures 14 inches from crown to callosities when sitting. Exactly the same condition of no scrotal bag or testicles to be easily felt was found in two other males I examined, one 14 inches high from crown to callosities, the other 11 inches. This condition in these four *Hylobates* males was very different from that of a young *Anthropopithecus troglodytes* I examined, as in this latter male the scrotal bag was large and well developed, being seen quite easily at a distance of fifteen feet, and both testicles could be felt easily.

It is to my mind most unlikely that four *Hylobates* males should arrive in the Gardens one after the other with abnormal external genital organs, and I think that in these cases the absence of scrotal bag and small size of the testicles during the early years of life were normal, and this opinion is strengthened by the condition of some young skins in the Natural History Museum, which I examined by kind permission of Mr. Oldfield Thomas. The skins in that collection are of different ages, sizes, and species (*H. hainanus*, *H. hoolock*, *H. lar*, *H. leuciscus*, *H. agilis*, *H. agilis martini* and *pileata*, *H. mülleri*, *H. leucogenys*, *H. gabriellæ*). Some of these skins, those of old males, have a large and conspicuous scrotal bag; in others, younger males, the scrotal bag is only beginning to form and not so obvious, while in some of the youngest skins, one of which is the male *H. hainanus* above mentioned, it cannot be seen or felt. In these the skin between penis and ischial callosities is perfect and has not been cut at all, so it is quite certain no scrotal bag existed during life.

The delayed development of the scrotal bag and diminutive size of the testicles correspond to the late commencement of menstruation, and on this latter subject few observations have been made in *Hylobates*.

I have compared the size of the skull as felt through the skin, and also the canine and other teeth, of the female *H. agilis* now living in the Gardens with skulls in the Museum which are obviously adult, and this comparison shows that the Society's female *H. agilis* is almost adult at the present time; although it has been in perfect health since arrival in December 1905, it has not yet begun to menstruate. Mr. Pocock has also recorded that the female *H. hainanus* previously exhibited did not begin to menstruate until almost adult (P. Z. S. 1905, vol. ii. p. 169), and from these two cases it seems to be the normal course that in *Hylobates* menstruation is delayed until a much later period than is normal in Man.

When the female *H. hainanus* just mentioned was living in the Gardens, I noticed that it was in proportion to height more slenderly built in both body and limbs than other species (such as *H. agilis*, *H. lar*, *H. leuciscus*, and *H. hoolock*) then or recently living. As the animal had one fore limb, which it rarely used, partially paralysed, I thought at that time the slender build was the result of poor health and not a specific character. This being the first female brought either alive or in skin to England, so far as was known, there was nothing to compare it with, but since then the male now in the Gardens arrived and showed the same slender body and limbs. As this male has been in perfect health since arrival in December 1907, and as its appetite is good and it has not become stouter at all, although it has grown taller, I think it is quite justifiable to state from these two living specimens that *H. hainanus* is more slenderly built in body and limbs than other species such as *H. agilis*, *H. lar*, *H. hoolock*, and *H. leuciscus*.

A comparison of the external genital organs of the male *H. hainanus* with those of *Symphalangus syndactylus* shows certain differences. In *H. hainanus* the distal half of the penis, which is covered by mucous membrane, is a dull red, making that organ very conspicuous in the otherwise jet-black coloration.

In *S. syndactylus* the penis is black all over, and both it and scrotal bag are very small indeed in proportion to the size of the animal. When hanging the penis is on a level with the ischial callosities, and not above them as in *H. hainanus*. In *S. syndactylus* the large tuft of long hair growing from below the penis and between the callosities, and spreading out as it runs downwards and backwards between the animal's legs, is most conspicuous, hiding a large part of the ischial callosities from view when the animal is hanging and seen from below. In the skins of *Hylobates* in the Museum the hair on the scrotal bag in old males is no longer than that on other parts of the body, except in one very aged *H. hoolock*, and in this single specimen it is not nearly so long in proportion as in *S. syndactylus*; in skins of *S. syndactylus* males it is very long indeed, as in our living male.

I might add that in *H. hoolock* and *H. leuciscus* the penis is black all over, even in the distal half covered by mucous membrane.

H. hainanus presents three points distinct from *H. hoolock* as shown in living specimens.

When Mr. O. Thomas described the type of *H. hainanus* (Ann. Nat. Hist. ser. 6, vol. ix. p. 146), he was doubtful as to the validity of the species of *Hylobates*; Mr. Pocock (P. Z. S. 1905, vol. ii. p. 169), from examination of a living female example of *H. hainanus*, supported the distinctness of the species, and my own observations on our living male confirm this.

The differences between living specimens of *H. hainanus* and *H. hoolock* are as follows:—

(1) *H. hainanus* is more slenderly built in body and limbs than *H. hoolock*, as I have already pointed out, even when in perfect health.

(2) In living males the colour of the penis is different. In *H. hainanus* the proximal half covered by the skin is black, and the distal half covered by mucous membrane is *dull red*. In *H. hoolock*, on the other hand, both proximal and distal halves are black.

(3) In two living specimens of *H. hoolock*, male and female, the hair on the crown of the head lay quite smooth and there was no erect crest whatever. In the male *H. hainanus* now alive the hair on the crown of the head stands erect in a crest, as it did in the female, as Mr. Pocock remarks (P. Z. S. 1905, vol. ii. p. 175).

I might add that the hair on the crowns of the living specimens of *H. agilis* and *H. leuciscus* is quite flat and there is no erect crest whatever. *H. hainanus* is the only species that I have yet seen which has an erect crest on the crown; it also has a short beard on the chin.

There are two points in *H. agilis* worth mentioning which are well shown in the female now living:—

(1) The tongue is of a dark bluish purple, the colour when first seen suggesting that the organ had been very severely bruised and that there was much extravasated blood in it; the absence of any swelling, however, soon showed it to be quite normal. In the other species (*H. hainanus*, *H. leuciscus*, and *H. lar*) the tongue is, as one would expect in a genus so near to Man, of a pale reddish colour, as is also the case in *Symphalangus syndactylus*.

There is considerable resemblance between young specimens of *H. agilis* and *H. leuciscus*, and consequently this dark bluish-purple tongue of *H. agilis* should be of value in distinguishing the species from *H. leuciscus*, in which, as already mentioned, the tongue is pale red. So far as I can discover, this peculiarly coloured tongue of *H. agilis* has not been previously noted.

(2) In addition to the common chatter of excitement and laugh which all species of *Hylobates* make, *H. agilis* has a loud cry, quite distinct from the "hoo hoo hoo" &c. of *H. hainanus* and the "hah hoo hah hoo" &c. of *H. hoolock* (see Pocock on *H. hainanus*, P. Z. S. 1905, vol. ii. p. 176), and I have not as yet heard either *H. lar* or *H. leuciscus* utter a similar sound. This peculiar cry of *H. agilis* is best described by a word "whopp," and is shouted out, the mouth being wide open and the throat conspicuously dilated. It is only uttered once and then silence ensues for about thirty seconds, then another "whopp," then a period of silence, then another "whopp," and so on. Usually this cry continues for about ten minutes, but a few times I have heard it continued for over an hour; and very occasionally the "whopp" is prolonged into a long loud screech lasting a minute or longer, the mouth being kept wide open the whole length of the screech and the throat dilated. I have never heard it uttered when playing or quarrelling with the *H. hainanus* (both species utter the common chatter at these times), but only when the *H. agilis* is swinging by itself. It is also a quite different sound from anything uttered by *S. syndactylus*.

The voice of *Symphalangus syndactylus* is remarkable for the variety of cries, which follow rapidly one after another, and at least five sounds can be distinguished, with all of which the gular bag dilates. Anyone with their eyes shut would certainly think there was more than one animal in the cage. These cries are:—

(1) The usual and loudest, best described by the words "woe, woe, woe," &c., repeated rapidly and for a variable number of times, sometimes forty or fifty. Judging from the deafening noise the animal made with the "woe woe" &c. on the first occasion I heard it, I should think it could be heard much further off than an adult *H. hoolock*, but unless one hears two adults shouting against one another, it is very difficult indeed to be certain which of the two has the louder cry.

(2) A gurgling noise, best described by the word "moo," drawn

out over several seconds and sounding somewhat like a human being beginning to vomit. It follows rapidly after the "woe, woe, woe," &c., as a rule, and the gular bag dilates to the greatest size with this sound, occasionally reaching a diameter of nearly 8 inches. The "moo" is made mostly during inspiration.

(3) What I can best describe as a wailing-shriek like the word "wair" shrieked out for twenty or thirty seconds and sometimes longer, the voice being alternately raised and lowered a little. It usually follows rapidly after the "woe, woe, woe," &c., and is about as often heard as no. 2—the gurgling "moo." It is, however, louder than the "moo."

(4) A "ho, ho, ho," &c., repeated, as a rule, four or five times. I have only heard it on a very few occasions and it is not nearly so loud as the previous three sounds.

(5) A squeal somewhat resembling the noise made by some Eagles. This is as rare as the "ho, ho, ho," &c., and not so loud as the first three sounds.

When at rest the gular bag is black in sunlight and slightly wrinkled, but on dilatation it becomes dull red. In its walk *S. syndactylus* is bipedal like *Hylobates*.

EXHIBITIONS AND NOTICES.

March 7th, 1911.

Dr. A. SMITH WOODWARD, F.R.S., Vice-President,
in the Chair.

THE SECRETARY exhibited a series of lantern-slides prepared from photographs kindly given to him by Mr. CARL HAGENBECK, Silver Medallist of the Society, and illustrating some of the most remarkable features of Mr. Hagenbeck's new Tierpark at Stellingen near Hamburg.

Mr. R. I. POCKOCK, F.L.S., F.Z.S., on behalf of Mr. ERNEST C. OBERHOLTZER, exhibited a large number of lantern-slides and photographs illustrating the habits of Moose. Mr. Oberholtzer had presented to the Society the series of enlargements exhibited and communicated the following account of

Some Observations on Moose.

Of late it has become almost a heresy to associate big game with any land but Africa. Like the bonneted old lady in the corner, even America, humiliated, lives in the past; the stride of the elephant steadily lengthens; and one would suppose that all save the jungle folk must soon be content with their barn-yards

and menageries. What a consolation, therefore, to find in the temperate zone a region where large wild animals are not only numerous but increasing! Such was my own good fortune in the forested lakeland tributary to Rainy Lake, Ontario, where I spent five months in 1909 and the month of June 1910, canoeing with a Red Indian. Besides numerous lesser animals, we saw of that largest Deer—the Moose—nearly 500; 275 of them in a single fortnight during the fly-season of 1910.

The Indians of this region all agree in saying that thirty years ago the Moose was a rare, if not almost unknown, inhabitant. Yet there are reasons to believe that at some remote time his dominion was not unlike the present. On many of the rocks, for instance, there are half-obliterated paintings attributed by the Indians to a medicine man named Amo, who lived vaguely "t'ousand years 'go"; and nearly all these paintings include the figure of a moose. The horns and the hump on the back are unmistakable.

The increase of the moose in the last thirty years has coincided with the decline of the Indians; the natives still surviving are generally a feeble lot, whose hunting-grounds are no longer far afield. From his worst enemy, therefore, the moose has had little to fear. Moreover, he has been almost without rival, for the woodland Caribou that once roamed all over the region has gradually withdrawn until to-day in a whole winter only an isolated band or so may be seen.

Another significant change in the region is the disappearance of wild rice (*Zizania aquatica*), called by the Indians "manomin." Formerly it was one of the Indians' chief foods; they gathered it in great quantities every autumn and it attracted hosts of ducks. To-day it is very rare; in three thousand miles of canoeing I saw it above water only two or three times and then always in small patches. The explanation, I think, is connected with the moose. Though writers never mention wild rice as one of his foods, there can be no doubt that in these parts at least it is a favourite. I remember one day we saw three moose feeding in a shallow bend of the river. When we had frightened them away, I said to my Indian: "Billy, there are no lily-pads here. What were they eating?" For reply, Billy thrust his arm under water and pulled up a bunch of light green grass—the same that I had seen hanging from the mooses' mouths. It was wild rice.

Wherever in the Rainy Lake District moose are seen in large numbers, careful investigation, I think, will reveal more or less of this same wild rice, half-developed under water. The moose, though they occur in all parts of the region, tend to congregate in these special feeding-grounds. I have seen ten together, seven of them bulls, in one bend of the Big Turtle River; and every one was feeding on wild rice.

Browsing in the river, the moose usually walks out to the height of his belly. If he feels no fear, he dips his head regularly for a period of from ten to thirty seconds and lifts it during one

to fifteen seconds; such, at least, were my conclusions, after roughly timing a number of feeding bulls. Not having a stop-watch, I arranged with Billy to signal me every time the animal either raised or lowered his head.

To get rid of flies, the moose often completely immerses himself. I have seen large bulls swim out beyond their depth, sink their heads, and be gone from sight a second or so, the hump reappearing first. The bulls, as a rule, venture out much farther than the cows; ten times to one where a moose is overtaken in deep water by canoe it is a bull. This is partly, I think, because the bulls have no responsibility in protecting the calves, and partly because they seem to be much more afflicted with flies than either cows or calves. Throughout June, July, and often the greater part of August, the head and withers are plastered with flies—particularly with little grass-green wedge-shaped flies. When the bull immerses himself they merely hang above the water till he reappears. Several times when we have overtaken a bull in mid-lake these flies have transferred themselves to our backs and there they stuck, stubborn to all slapping, till we smoked them off over the fire. The cows and calves, on the other hand, seem to be comparatively free from these pests; and I have often wondered whether the heat and blood in a bull's new antlers may not help to make him a target.

Last spring opposite our camp there was a bay, where we could see the moose come to feed morning, noon, and evening. They usually remained an hour or so, and often at night, too, we could hear them splashing and grunting. In general, however, though I have seen more moose at sundown than at any other time of the day, I have not found them confining their visits to any particular hours. If unmolested, many of the bulls during the fly-season seem to remain in the water the greater part of the day; even when disturbed they often return quickly. Nor do moose cease to enter the water when the flies are gone. I have seen a cow up to her belly on the first of November, a few days before the river froze. They have a fondness for tramping through the creamy grey ooze that covers the bottom of many streams. Often you will see it sticking to their legs when they stand on the shore; and I remember certain shallow lakes where the bottom was channelled in all directions with their furrows. Then, too, especially early and late in the year, they sometimes take long swims. Last spring I saw two crossing the lake at a place not less than two miles wide. In this way they often become an easy prey to pot-hunters; one of my own canoemen had thus slain a bull with an axe. Men have even been known to jump on the backs of swimming moose.

Of the extraordinary tameness of moose in regions where they are seldom molested there are many records. They seem to have a primitive curiosity about Man comparable to our own about them; and this is especially evident in the untravelled Rainy Lake District. Again and again we approached within fifty feet

without causing uneasiness; and four times we came as near as thirty feet in plain sight and took a dozen or more photographs. I even changed my roll of films.

The most singular experience occurred on the 2nd of October, 1909. It was about half-past four o'clock in the afternoon; the sun was low, and we were looking for a place to camp. All at once we heard the throaty grunt of a bull moose. Paddling quietly into a shady bay, what was our surprise to see a little yearling cow run out from the birch trees and come towards us whinnying! The next moment there was a loud crashing, and a tall heavy two-year-old bull broke through the trees with a rush. I took a photograph at once, for I thought they would turn and flee. Instead, as we drifted nearer and nearer, the little cow walked out toward us along the edge of the shore as if for protection. The bull, seeing us, checked his pace and waded stiff-legged into the water as high as his knees. In evident fear of him, the little cow kept whining and edging off, while he, advancing within fifteen feet of us, lowered his head, turned broadside with one eye on the cow, and sniffed at us suspiciously like a dog. The cow, as if satisfied with her temporary immunity, now began to feed. The bull made no attempt either to leave or to attack us. It was only at last when I spoke, after thirteen pictures, that they took fright; and then the cow, instead of running away with the bull, entered the water behind us and swam across to the other side.

The young moose, as a rule, seem to be less cautious than the old. On the 11th of June, 1910, we paddled up the river to the same bend, where the day before we had seen ten moose. This day there were seven, and one by one they walked slowly away into the woods, all except a little fellow that I mistook at first for a cow. When we glided nearer, I saw two round knobs of horns just peeping out of the forehead between his eyes and ears. They were his first antlers. As we approached, he fidgeted a little and looked at us with a mild sort of curiosity. Then down went his head—but only halfway, for the tips of the ears still protruded. Presently, completely reassured, he disappeared under water. He was down on his knees. When he rose, he shook his head till the long ears flapped against his cheeks. Then, whining softly and stretching his neck forward, he took a step toward us. I could almost have touched him with my hand; but Billy, always cautious, began to paddle backwards. Several times the little fellow tried again to approach us—for exactly what purpose I have never known. He seemed to be entirely friendly. At last I spoke, and away he went.

There is a theory among some sportsmen who have only shot moose that drooped ears are a sure indication of a wound. On the contrary, the moose lowers his ears for as many reasons as any other animal. Perhaps it is safe to infer that a moose with ears always drooped is injured; but the pictures of the friendly little bull show him with ears one moment erect, the next drooped, and again out straight. Sometimes they are lowered on account of

flies, sometimes to let the water run out, and almost invariably when the moose is either apprehensive or at bay. A cow with twin calves, which I photographed last spring, lowered her ears when she began to feel uneasy about our presence. We were only thirty feet away. At first she seemed not to mind; but the repeated click of the shutter alarmed her. She appeared to be wavering between friendliness and defiance. And I have observed the same behaviour repeatedly under similar conditions.

Indeed, the moose seems to be an animal of mixed emotions. Unlike the White-tailed Deer, he seldom bounds away at first sight of man. He will have a good second look unless there is immediate danger. Curiosity or indolence, or even friendliness (and I really believe in the last motive), frequently holds him until he has had proof of evil intentions. Often, having crept up stealthily upon a moose either by canoe or through the bush, I have been amused to find that he was watching me wide-eyed all the time. How often too, while the canoe passed, I have seen them peering out unalarmed from behind their ambush. And certainly the more they see of men without suffering injury, the more careless they become. Passing up and down the same eight-mile stretch of river at least once a day, last June, I was surprised at the change that occurred in a week. At first I could never get nearer than a hundred yards. We always went quietly and with as few motions as possible, and we never pursued an animal that had taken fright. At the end of the week hardly one of them would budge until we were within seventy-five feet; and if we returned half an hour later, there they were again in the water. Some of them never left, unless we turned toward them.

When we frightened them, it was either by unusual noises, sudden movements, the scent of our bodies, or above all by the sound of the human voice. No doubt, experience of the gun changes the order; the scent then becomes of first importance. I believe, though, that there is nothing alarming in the scent itself except as it is novel or as it recalls deadly memories. The cow and calves of which I spoke above may not have scented us, for there was a slight breeze in our favour. With the young bull in the water and the other bull and cow calf it was different. In the former case the breeze blew straight away from us; in the latter there was no perceptible breeze at all, but it would be idle to question the powers of a sniffing bull at from 15 to 20 feet. It is only the human voice, so far as I can discover, that never fails the first time to cause a panic. Whenever otherwise we were admitted to the closest intimacy, it broke the spell at the first word. There seems to be something unearthly about it that jangles the moose to the very heart.

A peculiar feature of the moose is the bell. Mr. E. T. Seton, in his memorable 'Life Histories of Northern Animals,' cites a bell 18 inches long as unusual. For an average of all moose, young and old, it certainly is; but, without actual measurements, I have a strong impression nevertheless that for bulls of three,

four, and five years even two feet is not rare. In cows and yearling bulls the bell is usually small and delicate. In bulls a few years older I have often seen it swinging like a tassel. It is the old bulls with large fully-developed antlers—the bulls usually sought by sportsmen—that have no more than a thick stump of a bell. The Indians believe, as Mr. F. C. Selous suggests in his 'Recent Hunting Trips in North America,' that it gets torn off or dries up. Perhaps both may happen, or it may even freeze off during the winter.

Except some of the yearlings and an old mother or so with calves, the moose in the Rainy Lake District are all fat and sleek. In September they fairly bulge. They seem lazy and satisfied, as if they had found the true land of plenty. They are not too indolent, however, for play—at least not the younger ones. Once, in June, I saw two of them (young bulls, I think, though I was too far off to be sure) frolicking on a sand beach. They cantered and reared and stopped short and wheeled round exactly like young horses, and at last, without warning, bolted into the bushes. Again, in September I saw a half-grown grey calf cavorting on the edge of a bay. A very fat cow and a huge glossy bull in full armour stood ankle-deep in the water, gazing at each other in stupid indecision. They seemed to be equally infatuated. The little calf meantime enjoyed all manner of caprices, just as if he considered his mother's new company a stimulating adventure for himself. It reminded me of an exuberant boy tossing his hat in the air.

During the rutting-season also we once tried the effect of the much-discussed "calling"—an art almost unknown in this region. It was a warm afternoon—about three o'clock on the 30th of September. We had just paddled a hundred yards or so beyond a portage, when we heard the low, languorous, lustful, two-noted grunt of a bull. In spite of the sun in our eyes, we thought we saw him on the shore about three hundred yards to the right of us. My Indian with unaided voice gave what seemed to me a perfect imitation. Immediately, we heard the moose reply and waded out into the water. The Indian repeated the call several times, and the bull began to swim leisurely toward us. The call sounded so easy that I could not resist trying myself. This seemed to make no difference. The moose swam straight toward us. We then kept still. When he was about one hundred feet away (a three-year old bull, as we judged), he suddenly caught sight of us. With evident surprise he turned and swam swiftly for shore. Whatever else he had expected, I am sure he had had no thought of man—even though my own call, at least, must have been seriously defective. I should conclude, therefore, with Mr. Selous that, where moose are unaccustomed to being deceived, a bull in a state of frenzy may be attracted sometimes by other sounds than the perfect call.

The moose, like all creatures, sometimes makes fatal miscalculations. A real tragedy was recently reported to me in a letter from

Mr. Louis Hamel, Postmaster at Mine Centre, Ontario, to whom my Indian sells furs. He said that, early in the winter, Billy, having gone up the river where we counted so many moose last spring, saw some twenty of them frozen in the ice. Evidently they had tried to cross too early and had broken through. Perhaps no one moose would have misjudged the strength of the ice for his own weight; but it is rare for such large numbers to travel together. Like men, sometimes, on a stage, they had forgotten to reckon the combined pressure.

Such accidents, happily, are rare. There can be no doubt that moose are plentiful in all parts of the vast Rainy Lake District; for, though one may travel several days or more without seeing the animals themselves, the signs are everywhere. If one forgets, however, that the moose tend to congregate in certain favourite feeding-grounds, it is easy from various record tallies to over-estimate their total number. It is true that I saw 44 in one day during the fly-season; but, on the other hand, during five months' travel the previous year, I had never seen more in a single day than eight.

If moose were once before plentiful in this region long ago, as some people suppose, there is no certainty that the present conditions are permanent. Whatever swept them away before, whether wolves, or men, or pestilence, may recur. One thing seems sure—year by year they are pushing farther north toward the edge of Hudson Bay. Perhaps in time by this very movement their southern range will be deserted; but more likely they are merely recovering old ground by force of expanding numbers. Wolves in the Rainy Lake District are still scarce, the Indians cannot return, and the shooting-season—perhaps unnecessarily late—comes at a time (Nov. 1st to 15th) when the danger of freezing lakes keeps sportsmen close to the settlements. All these safeguards together with the ideal character of the country—its innumerable lakes and rivers and its abundant food-supply—seem almost to ensure the perpetuation of this noblest of American game animals.

In the very heart of the region, too, Ontario and Minnesota have wisely set aside contiguous tracts of more than 3500 square miles, where the moose are protected for all time. Thus, even with the inevitable increase in shooting, and the probable establishment of an earlier open season, the prospects for the future are auspicious. It is a pleasant and noteworthy coincidence that that animal which writers invariably describe as "prehistoric-looking" should have proved among the ablest in modern times to hold its own.

PAPERS.

19. Some New Siphonaptera from China. By KARL JORDAN, Ph.D., F.E.S., and the Hon. N. CHARLES ROTHSCHILD, M.A., F.Z.S., F.E.S.

[Received and Read March 7, 1911.]

(Text-figs. 104-124.)

The following fleas were collected by Mr. M. P. Anderson in the provinces of Shensi, Kansu, and Sze-chuen, China. The collection contains altogether 17 species, of which no fewer than 13 are new. Some of these are closely related to species described from Turkestan or European Russia, and may possibly be only geographical developments, others represent very distinct types not very nearly allied to anything known from other countries.

1. *ARCHÆOPSYLLA SINENSIS*, sp. n. (Text-figs. 104, 105.)

♂ ♀. Agrees in both sexes very closely with *A. erinacei* Bouché (1833) from Europe, differing chiefly in the following points:—

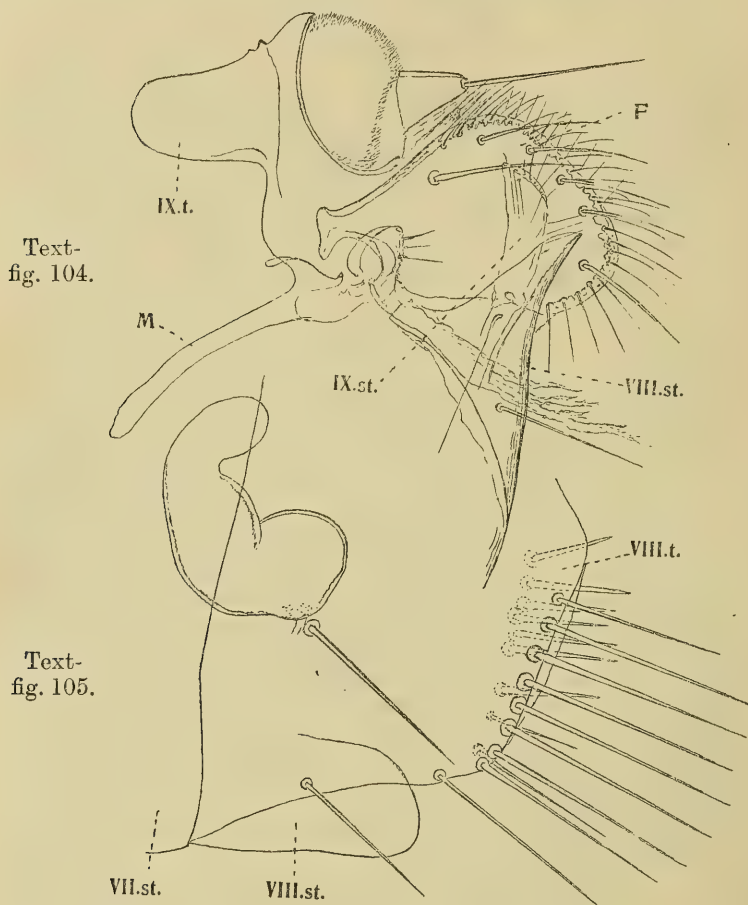
The tooth situated in *A. erinacei* at the apex of the genal lobe of the head below the antennal groove is either absent from *sinensis* or small and very pale. The receptaculum seminis of the female (text-fig. 105) is slightly smaller than in *erinacei*, and the modified abdominal segments of the male exhibit some easily recognisable characteristics as follows:—The ninth tergite, which in *erinacei* has a short, broad, and curved manubrium, bears a broad and straight manubrium with rounded apex (text-fig. 105, IX. t.). The ventral margin of the eighth sternite is not denticulate. The large movable process (F) of the clasper is much shorter than in *erinacei*, and its ventral edge, instead of being continued downwards as a broad thin flap which is slit at the margin into filaments, bears only a narrow membranaceous appendage. The ninth sternite (IX. st.) is less rounded at the apex than in *erinacei* and has more bristles. As this sternite is partly concealed in our specimens by other organs, we are not quite certain that our figure gives the exact outline of it.

A small series of both sexes from Yu-lin-fu, Shensi, 4000 ft., taken off *Erinaceus miodon*.

2. *CERATOPHYLLUS CRISPUS*, sp. n. (Text-figs. 106-108.)

♂ ♀. The male of this species shows some very remarkable specializations not observed in any other known flea, the second segment of the antenna bearing in that sex some very long and strong bristles which extend far beyond the long club, and the posterior margin of the hind coxa being incurved at some distance from the base. Moreover, the hind tarsus of the male exhibits a development of the bristles which is only approached to some extent in the males of two species of the genus *Vermipsylla*. The female of *C. crispus*

does not exhibit any trace of these specializations. The bristles of the second antennal segment of the female are all short, and the hind coxa and tarsus are quite normal. It agrees, however, with the male in other characteristics—for instance, the long rostrum and relatively short maxillary palpus, the absence of a row



Text-fig. 104.—Clasper of *Archaeopsylla sinensis* ♂.

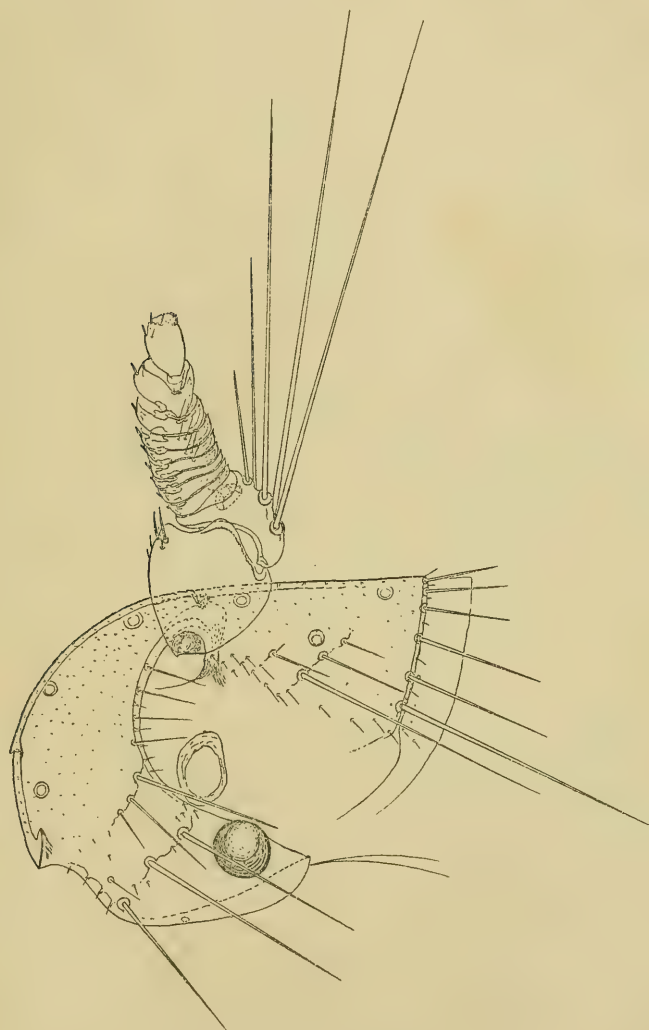
Text-fig. 105.—Abdominal segments VII & VIII and receptaculum seminis of *Archaeopsylla sinensis* ♀.

of bristles on the inner surface of the mid and hind femora, the presence of two rows of lateral bristles on the hind tibia, the relatively short first mid-tarsal segment, &c.

We may mention incidentally, in connection with the drawing

of the head (text-fig. 106), that the antenna moves on a pivot standing almost at right angles to the first segment. For that reason the antenna cannot assume a position at right angles to

Text-fig. 106.



Head of *Ceratophyllus crispus* ♂.

the lateral surface of the head, but, when moved from the antennal groove, slides along the side of the occiput until the

position is reached which it has in our drawing. The hind side, which bears the long bristles, is nearest to the eye when the antenna is in the groove, and it is always the outer surface which is presented.

Head.—The rostrum is a little longer in the ♀ than in the ♂. It reaches beyond the trochanter in both sexes, the apex of the fourth segment being on a level with the base of the trochanter and the last segment being more than twice the length of the fourth. The maxillary palpus extends to the third segment of the rostrum. The bristles of the head are almost the same in number in the sexes (*cf.* text-fig. 106), but are less strongly developed in the ♀ than in the ♂; moreover, the thin bristles at the anterior edge of the antennal groove are not present in the ♀, and of the four bristles placed in the ♂ above the antennal groove (1, 3) the anterior one is absent, and the large ventral one of the row of 3 is accompanied by but one bristle, which is small. The first antennal segment of the ♂ bears on the inner surface a number of small bristles along the anterior edge, and the outer surface of this segment of the ♀ has numerous small hairs. The second antennal segment of the ♀ bears one row of short hairs, these hairs being very thin and only reaching to the second segment of the club. In the ♂ this segment has several very long bristles, as shown in the figure.

Thorax.—The pronotal comb consists of 18 to 20 spines. The meso- and metanotum bear each two rows of bristles and a number of additional short bristles which represent three more rows on the mesonotum and two on the metanotum, being less numerous on the latter than on the former. The mesonotum has on the inner side eight slender spines on the two sides together. The mesopleura bear 9 to 11 bristles, the metepisternum 3 and the metepimerum 7 or 8 (3, 3 or 4, 1). There are 2 or 3 apical spines on the metanotum on the two sides together.

Abdomen.—The four to six anterior tergites bear apical spines, the numbers being (on the two sides together) in the ♂ 2—3 or 4—2—2—2—0 or 2, and in the ♀ 2 or 3—2 to 4—2—2. The apical edge of segments I to VII is distinctly denticulate in both sexes. There are two rows of bristles on the tergites. The stigmata are placed above the first bristle of the second row, and below the first of the anterior row. The ♂ has one very long antepygial bristle accompanied by two short but strong ones, the upper one being the shortest. The ♀ also has three antepygial bristles, of which the upper one is half and the lower one two-thirds the length of the central bristle, which is as long as the first hind-tarsal segment. The first sternite has (on both sides together) two bristles, sternites III to VII bearing in the ♂ 6 bristles, and III to VI in the ♀ 6 to 8, while VII has 10 to 12 in the ♀, with one or two small bristles in front of this row, there being no additional bristles or quite exceptionally one bristle on the other sternites.

Legs.—The hind margin of the hind coxa of the ♂ is incurved from one-fourth of the margin to its centre. The mid- and hind femora bear on the inside one lateral bristle, placed at the basal third, and on both sides one subapical ventral bristle. The hind tibia has a double row of 13 to 16 bristles on the outer surface and a single row of 5 to 7 on the inside. The outer dorsal bristles, 18 in number inclusive of the apical one, are stout, most of them being less pointed than usually and nearly all being of more or less the same length. The longer bristles have likewise blunt tips. The longest apical one hardly reaches to the subapical notch of the first hind-tarsal segment. The first segment of the mid-tarsus is distinctly shorter than the second. The fourth segment of the fore- and mid-tarsi is only as long as it is broad, that segment of the hind tarsus being one-tenth longer than broad in the ♀ and about one-fifth in the ♂. The fifth segment bears in all the tarsi five pairs of lateral bristles. The hind tarsus of the ♂ is remarkable for the peculiar development of the bristles. The bristles on the upper surface and at the hind edge of these segments are thin and those placed in the notches of the hind edge and at the apex are long, the longest bristles, moreover, being wavy. There are eight bristles each dorsally at the apex of the second and third segments. These bristles radiate in fan-shape, the one placed at the anterior apical corner deviating but little from the general direction of the tarsus and being the shortest of the row, the others gradually increasing in length as one proceeds from the anterior to the posterior side of the segment, the longest about equalling segments 3, 4, and 5 together. The bristles on the tarsi of the ♀ are all short, the apical ones of the second hind-tarsal segment not reaching even to the apex of the third segment. The proportional lengths of the segments are as follows:—

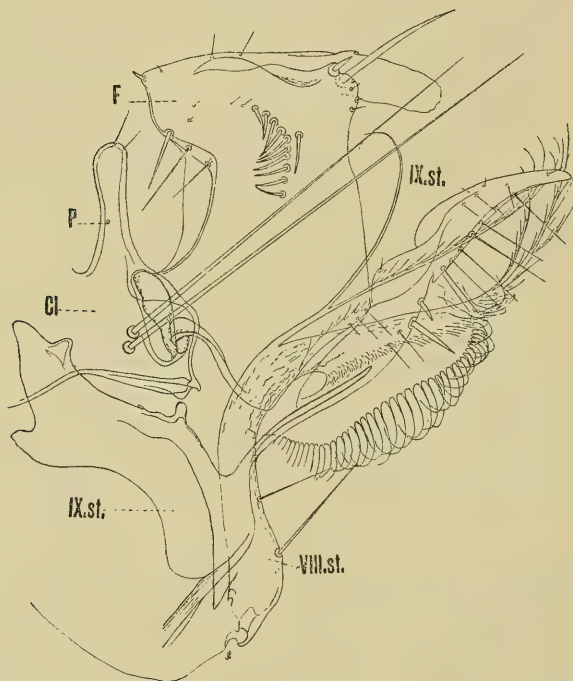
Mid tarsus: ♂. 18, 20, 11, 7, 19; ♀. 17, 20, 11, 7, 19.

Hind tarsus: ♂. 50, 39, 14, 9, 21; ♀. 47, 38, 16, 10, 22.

Modified segments.—♂. The eighth tergite bears about 20 bristles in the upper half of the apical lobe and none in the lower half. The eighth sternite (text-fig. 107, VIII. st.) is narrow and curved, and bears ventrally two bristles. Its distal portion is membranaceous and divided into a large fringed flap and several long filaments as indicated in the figure. The clasper (text-fig. 107, Cl) is small and is produced into a vertical, slightly club-shaped process (P), which bears two small hairs. The movable process (F), on the other hand, is very large and presents two remarkable structures. The upper edge, is, as far as we can make out, widened into a membranous appendage which projects distally and does not bear any hairs. The other peculiarity is the presence of a row of short spine-like bristles on the outer surface of the "finger." The ninth sternite (text-fig. 107, IX. st.) has a broad, curved vertical arm and a long and relatively narrow horizontal arm, both being of a characteristic shape. The distal portion of the horizontal arm narrows almost to a point.—

♀. The apical margin of the seventh sternite is slanting and more or less undulating, the two sides not being exactly alike. The ventral angle of this sternite projects more or less strongly and is sometimes almost pointed (text-fig. 108, VII. st.). The eighth tergite (VIII. t.) bears on each side only 4 to 7 small bristles above the stigma, and below it one long one accompanied by one to four small ones. There are 12 bristles on the lower half of the segment as shown in the drawing (text-fig. 108). The apical margin is angulate below the centre and the upper angle more or

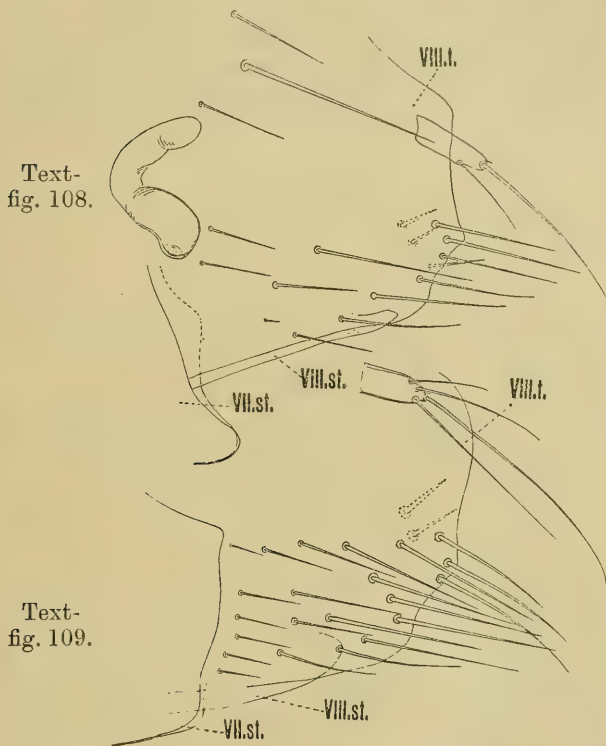
Text-fig. 107.

Clasping organs of *Ceratophyllus crispus* ♂.

less rounded off. The ninth sternite—more or less membranaceous and lying inside the eight tergite—bears some small hairs. The stylet is almost cylindrical and bears one bristle beside the apical one. The anal sternite has 4 very long bristles at and near the apex and proximally to them, on the underside, about 6 heavy spine-like bristles, besides a number of short lateral and ventral bristles, of which some are thin and others stout. The receptaculum seminis (text-fig. 108) is slender, the head being shorter than the tail.

Length (mounted specimens) 2·4 to 2·8 mm.

Two males and four females from Omi-shan, Sze-chuen, 6000 ft., off *Sciurotamias davidianus consobrinus* M.-Edw., and from 23 miles S.E. of Ta-tsien-lu, 7500 ft., off the same host.



Text-fig. 108.—Abdominal segments VII & VIII, stylet and receptaculum seminis of *Ceratophyllus crispus* ♀.

Text-fig. 109.—Abdominal segments VII & VIII and stylet of *Ceratophyllus dolabris* ♀.

3. CERATOPHYLLUS DOLABRIS, sp. n. (Text-figs. 109, 110.)

♂ ♀. Nearly allied to *C. lagomys* Wagn. (1897), of which only the ♂ is known to us. The new species is distinguished from that sex of *lagomys* by the shorter bristles of the eighth abdominal sternite, the differently shaped non-movable process of the clasper, the much narrower distal portion of the ninth sternite, the broader lobes of the anal sternite, and some other details mentioned below. The most characteristic feature in both *lagomys* and the new species is the development of the tenth abdominal sternite of the ♂. This sternite consists in fleas normally of a

single sclerite. In the males of the species under discussion, however, it is completely separated in the mesial line into a right and left lobe, which are very long and slender, projecting far beyond the tenth tergite, and bearing numerous bristles on the upper and lateral surfaces but none on the underside.

Head.—The frontal tubercle is prominent. There is a row of 3 long bristles in front of the eye. The occiput bears one long bristle above the antennal groove, besides the subapical row of bristles. The bristles on the second segment of the antenna of the ♀ are long, there being at least five which reach beyond the club. The rostrum extends to the base of the femur and the maxillary palpi reach the trochanter.

Thorax.—The comb of the prothorax consists of 17 or 18 spines, there being usually an additional small spine on each side. The meso- and metanotum have on the two sides together a posterior row of 12 bristles, and before it a row of about 6, the mesonotum bearing in addition a row of hairs at the base and several short bristles on the back. The metanotum has four apical spines on the two sides together. There are from 4 to 6 bristles on the metepimerum (1 or 2, 2 or 3, 1), usually 4 or 5.

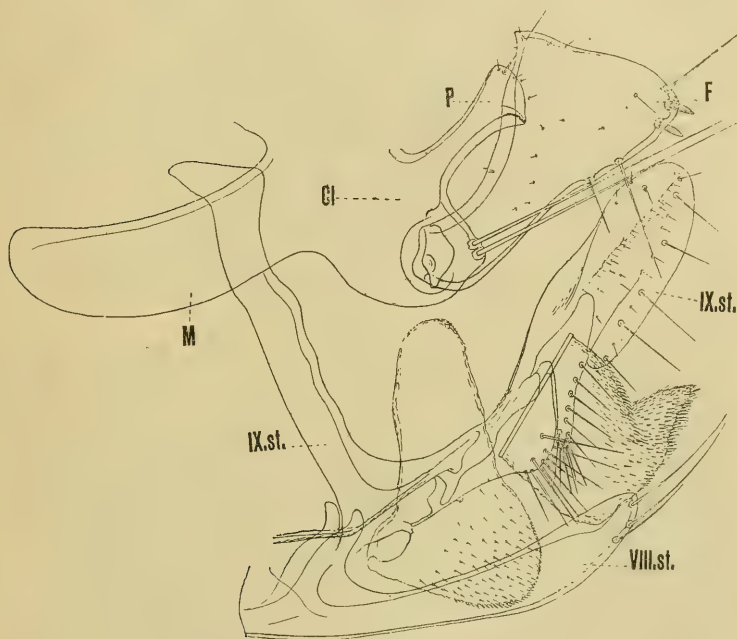
Abdomen.—The tergites bear each two rows of bristles, the first tergite having 2 or 3 additional bristles in front of the rows. On none of the tergites does the anterior row extend down to the most ventral bristle of the posterior row, the row stopping short at the third or fourth bristle of the posterior row on the central segments in the ♂, and at the second or third in the ♀. Tergites I to IV or V bear apical spines like the metanotum, the numbers being on the two sides together, 4—4 to 6—4—2 to 4—0 to 2. The ♂ bears one long antepygidial bristle accompanied by two minute hairs, while the ♀ has 3 bristles (all broken on both sides in our only ♀). The bristles on the sternites number on the two sides together in the ♂ 2, 6, 7, 8, 8, 8, and in the ♀ 5, 9, 11, 11, 11, 15, there being 16 additional bristles on the seventh sternite of the ♀, which are placed irregularly in front of the row. The stigmata in the ♀ are placed a little above the first bristle of the posterior row of the tergites or on level with it, in the ♂ below it on the posterior segment.

Legs.—The hind femur bears on the outer side one subapical ventral bristle and in the anterior half one or three lateral ones. On the inner surface there is a row of 9 to 12 bristles. The hind tibia has outside a row of 8 or 9 lateral bristles and on the inside a row of 4 to 7. The longest apical bristle of the second hind-tarsal segment reaches beyond the apex of the third. The fourth hind-tarsal segment is nearly twice as long as it is broad near the apex.

Modified segments.—♂. The eighth tergite has 3 bristles below the stigma, a row of 6 to 8 at the upper edge of the apical lobe, with 1 or 2 bristles close to the row, and an oblique and more or less irregular row of 5 or 6 near the ventral edge. The eighth sternite (text-fig. 110, VIII. st.) is similar to that of *C. lagomys*.

It bears, as in that species, three bristles at the apex on each side. While the two longest of these bristles are, however, half the length of the sternite in *lagomys*, they measure only about one-third the length of the sternite in the new species. The clasper is much the same as in *C. lagomys*, but the process (P) (text-fig. 110) is much more incurved on its distal side and hence the lower corner of the widened apical portion more pointed. The upper edge of the triangular movable process (F) (text-fig. 110) is less rounded than in *lagomys*, the two spines are pointed, and the long bristle of the distal edge is placed farther away from

Text-fig. 110.

Clasping organs of *Ceratophyllus dolabris* ♂.

them than in *lagomys*. The ninth sternite (text-fig. 110, IX. st.) is characterised, as in *C. lagomys*, by the central ventral lobe of the horizontal arm bearing a number of rather strong, short bristles at the apex. The thin, pale, distal lobe is more rounded than in *lagomys* and much broader.—♀. The seventh sternite (text-fig. 109, VII. st.) is truncate and slightly incurved twice. The eighth tergite (VIII. t.) bears 5 to 6 bristles below the stigma in two rows and has the upper angle of the apical lobe strongly rounded, the centre of the apical margin being somewhat triangularly produced as shown in the figure. The bristles of the

stylet are long, the one placed near the ventral edge (side-view) being exceptionally long.

Length (mounted specimens) 2.5 to 3.2 mm.

Three males and one female from Old Tau-chow, Kansu, 9000 ft., off *Marmota robusta* M.-Edw.

4. CERATOPHYLLUS CRASSUS, sp. n. (Text-fig. 111.)

The only specimens (two females) which we have were in the same tube as the specimens of *C. dolabris*, being found on the same host, presumably on the same individual of the host. They resemble the female of *C. dolabris*, but are much more hairy and of stronger build.

Head.—The frons bears a row of three bristles before the eye, the upper two standing rather close together and there being a fourth bristle in front of the ventral one of the row. The occiput bears a moderately long bristle above the antennal groove, about 10 small hairs along the groove, one of them being longer and thicker, and the usual subapical row. The two lower bristles of this row are large and there is a wide interspace between them and the next bristle of the row. The bristles of the second antennal segment are long, at least five of them reaching the apex of the club. The frontal tubercle is prominent. The maxillary palpus extends to near the apex of the fore coxa, while the rostrum reaches far beyond the trochanter, the apex of the fourth segment being on a level with the base of the trochanter.

Thorax.—The pronotal comb consists of 20 to 23 spines. The meso- and metanotum bear each two rows of bristles. The bristle-like spines on the inner surface of the mesonotum are very numerous (14 to 16 on the two sides together).

Abdomen.—The tergites bear three rows of bristles, the anterior row being more or less irregular, the second reaching down to the stigma and the third row having 2 or 3 bristles placed below the stigma. The tergites I to IV or V bear apical spines like the metanotum, the numbers on the two sides together being 4—5 to 7—4 to 6—2 to 5—0 or 1. The edges of the tergites are irregularly excised dorsally, but do not show any distinct minute serration as is usually the case in the allied forms. There are three antepygial bristles (broken in our two specimens). All the sternites have additional bristles in front of the usual posterior row, the numbers of bristles being as follows on the two sides together (the first number referring to the additional bristles of each segment): 5 or 6, 6 to 8—19 to 21, 16 or 17—22 to 24, 15 to 17—22 to 26, 14 to 16—22, 15—18 to 22, 19.

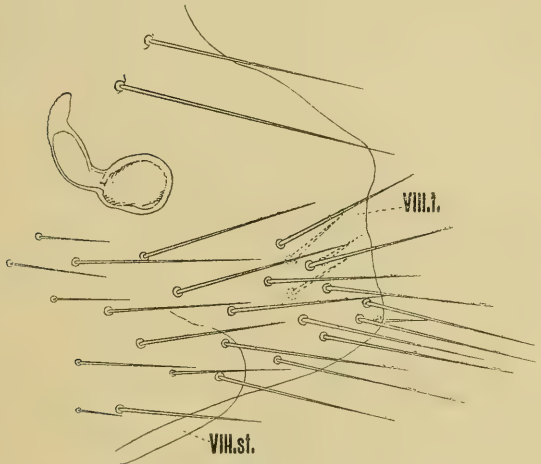
Legs.—The hind femur bears on the outside a row of 5 or 6 bristles and on the inside a row of 11 or 12. The hind tibia has 11 lateral bristles on the outside and 8 on the inside. Two of the bristles of the second hind-tarsal segment reach beyond the apex of the third. The fourth segment in all tarsi is only one-

third longer than it is broad near the apex. The measurements of the tarsi are :—

Mid tarsus : 28, 24, 20, 13, 30.

Hind tarsus : 58, 36, 26, 17, 33.

Text-fig. 111.



Abdominal segment VIII and receptaculum seminis of *Ceratophyllus crassus* ♀.

Modified segments.—♀. The seventh sternite is so much torn in both our specimens that it is not safe to express an opinion about its outline. The eighth tergite (text-fig. 111) bears two long bristles below the stigma and its apex is obliquely truncate and slightly incurved. The bristles on the lower half of the eighth tergite are numerous, and there are 3 or more short strong bristles on the inner surface. The stylet resembles that of *C. dolabris*, sp. n., but the apical bristle is appreciably shorter and thinner. The receptacle has a rounded head, which is shorter than the (artificially?) distorted tail.

Length (mounted specimens) 3·8 to 4 mm.

Two females from Old Tau-chow, Kansu, 9000 ft., off *Marmota robusta* M.-Edw.

5. CERATOPHYLLUS MANDARINUS, sp. n. (Text-figs. 112, 113.)

♂ ♀. A pale species with long rostrum, long tarsal bristles, a very long and narrow movable process in the male genitalia, and a peculiarly long-tailed receptaculum seminis with a small head in the female.

Head.—The frons is very feebly rounded in both sexes, the

frontal tubercle being placed at one-third or one-fourth the distance from the oral corner to the antennal groove. There are two long bristles in front of the eye, one of them standing near the eye and being accompanied by a much shorter bristle, and the others being placed at the oral margin. Further frontad there are two more bristles in the ♂, but not in the ♀, one of them at the oral margin behind the maxillary palpus and the other near the antennal groove. On the occiput there is one bristle above the antennal groove, and along the groove about half-a-dozen small hairs in both sexes. The apical row of bristles contains 1 long and 3 or 4 small ones, the interspace between the long (ventral) bristle and the next one being large. The third segment of the maxillary palpus is comparatively long, being only one-eighth shorter than the second segment. The rostrum reaches well beyond the trochanter, the proportional lengths of the segments being, 16, 15, 15, 27, and 40.

Thorax.—The pronotum has a comb of 18 spines (in one of the females 23) and a row of 12 bristles on the two sides together. On the mesonotum the postmedian row consists also of 12 bristles, while the row before it contains from 8 to 10. Near the base of the mesonotum there are only 14 small hairs in the ♂ and 24 in the ♀, while the inner surface bears near the apex from 9 to 12 bristle-like spines. The mesopleura bear five long bristles and anteriorly a few small hairs in addition. The numbers of bristles on the metanotum are 12 in the postmedian row in both sexes, 3 to 5 in the anterior row in the ♂ and 9 to 11 in the ♀. The metepisternum bears 2 or 3 bristles and the epimerum 5 (2, 2, 1). There is on each side one apical spine on the metanotum, as on the first to third or fourth abdominal tergites.

Abdomen.—The tergites I to VII bear in the ♀ each two rows of bristles, the postmedian row containing 13 or 14 bristles on the central segments; in the ♂ the anterior row is reduced to 4 to 6 bristles on the first to fourth segments and to one or two on segments V and VI. The seventh tergite bears on each side in the ♂ one long antepygial bristle accompanied by two minute hairs, and in the ♀ two long bristles, of which the lower one is a very little shorter than the other. The numbers of bristles on the sternites are in the ♂ 2—4 to 6—6—6—4, and in the ♀ 2—12 to 14—8—7 to 10—8—13 or 14, there being 3 or 4 small bristles in front of the row of the seventh segment on the two sides together.

Legs.—The hind femur has on the outside two lateral bristles and one subapical one and on the inside a row of 7 or 8 bristles. On the hind tibia there is one lateral row on the outside, containing in the ♂ 7 bristles and in the ♀ 5 to 8, the inner surface bearing a row of 4 to 7 in the ♂ and of 6 to 8 in the ♀. The first mid-tarsal segment is the same in length as the second. The longest bristle of the first hind-tarsal segment reaches at least to the apex of the second, and this latter segment bears two apical bristles which extend considerably beyond the

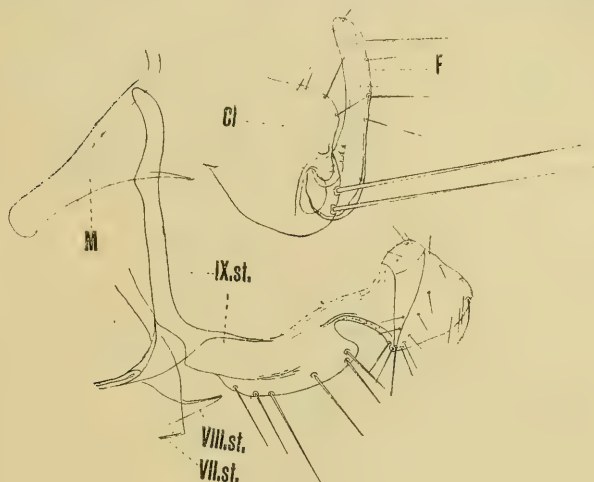
apex of the fourth. The proximal pair of bristles of the fifth segment is lateral like the other pairs. The proportional lengths of the tarsal segments are :—

Fore tarsus : ♂ . 10, 12, 10, 8, 22 ; ♀ . 12, 15, 12, 10, 24.

Mid tarsus : ♂ . 18, 18, 14, 9, 22 ; ♀ . 24, 25, 18, 10, 26.

Hind tarsus : ♂ . 49, 32, 20, 12, 24 ; ♀ . 60, 37, 23, 14, 30.

Text-fig. 112.

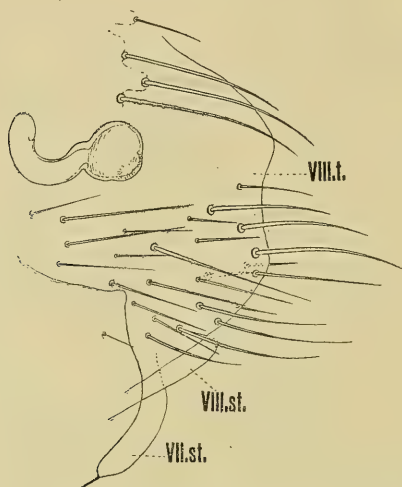


Clasping organs of *Ceratophyllus mandarinus* ♂.

Modified segments.—♂. The eighth tergite bears at the upper edge beyond the stigma a row of four long bristles, from the last bristle towards the sides of the segment there are two bristles, another stands below the stigma and two are situated near the ventral edge. The eighth sternite (text-fig. 112, VIII. st.) is small, being distally suddenly narrowed to a point in lateral aspect and bearing no bristles. The clasper (text-fig. 112, Cl) is broad, its upper angle rounded and not produced into a process. The manubrium is at first strongly narrowing from the clasper inward and then remains almost of even width; its apex is slightly curved downwards and has the upper angle more strongly rounded off than the lower angle. The movable process (F) is very long and of practically the same width throughout. It is but slightly curved and its tip rounded off. This finger bears a short bristle at the tip, a long one below the tip at the distal or ventral margin, and a third short bristle further down, then follow another short one, a moderately long one and another a little shorter than the preceding one. This last bristle is situated a short distance beyond the centre of the margin of the finger, there

being in one of the specimens another bristle lower down. The vertical arm of the ninth sternite (IX. st.) is very slender, especially the upper portion, which lies at the manubrium of the clasper. The ventral arm is divided by a ventral sinus into a longer proximal portion and a shorter and broader distal portion, the latter being about as long as it is broad. The proximal portion bears at the ventral margin 5 or 6 bristles, the two distal ones of which stand close together one on each side, and are fairly stout in comparison with their length.—♀. The seventh sternite

Text-fig. 113.



Abdominal segments VII & VIII and receptaculum seminis of
Ceratophyllus mandarinus ♀.

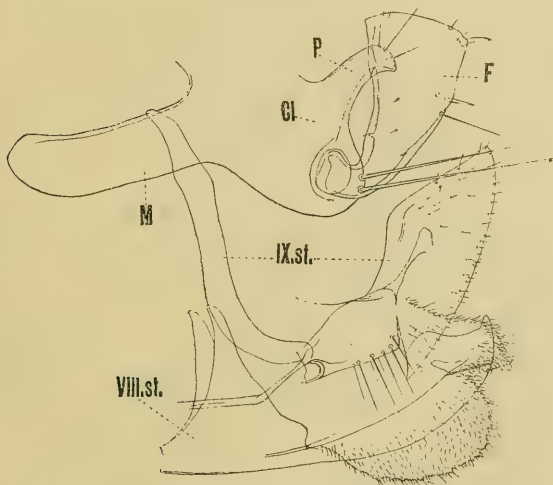
(text-fig. 113, VII. st.) narrows in side-view; its apex is truncate, somewhat obliquely, and slightly emarginate, with the upper apical angle quite distinct. The eighth tergite bears 8 to 10 small bristles above the stigma, 2 or 3 long ones beneath the stigma besides some small ones, and there are about 12 long bristles and 10 to 12 shorter ones on the lower half of the segment. The stylet is twice and one-half as long as broad. The bristles on the ninth and tenth tergites (which segments are separated by a distinct suture) are numerous. The receptaculum seminis is distinguished by the head being nearly three times as wide as the tail and only half its length. It has been disturbed in its position by the mounting in both specimens which we have, and the outline we give does not exactly represent a true lateral aspect of the organ.

Three males and two females from Yu-lin-fu, Shensi, 4000 ft., taken off *Citellus mongolicus*.

6. CERATOPHYLLUS MONGOLICUS, sp. n. (Text-fig. 114.)

♂ ♀. A single pair in the collection agrees well with *C. tesquorum* Wagn. (1893), except in the details mentioned below. The new species is smaller and paler than *C. tesquorum* and bears, on the whole, fewer bristles. The rostrum reaches a little beyond the trochanter in both sexes and is therefore longer than in the species mentioned. The abdominal sternites III to VI have each a row of 6 bristles on the two sides together, the ♀ bearing one or two additional bristles on each side of the sixth segment. The hind femur has on the outside one (♂) or two (♀) lateral bristles in the basal half and a subventral bristle before the apex, and on the inner side a row of 8 or 9 bristles. The hind tibia, which has a double row of about 11 bristles on the outer surface in *C. tesquorum*, has only 8 lateral bristles in *C. mongolicus* inclusive of the apical one. The first mid-tarsal segment is distinctly shorter than the second.

Text-fig. 114.

Clasping organs of *Ceratophyllus mongolicus* ♂.

The differences in the male genitalia are slighter than they generally are in distinct species. The non-movable process of the clasper (text-fig. 114, P) is a little slenderer than in *C. tesquorum*. The finger (F) is triangular as in that species, and bears the same bristles, but it is less widened at the apex, the upper (=apical) margin being one-fourth shorter than in *tesquorum*, the proportions of length and width of the finger being 7:4 in *mongolicus* and 7:5 in *tesquorum*. The eighth sternite of *tesquorum* is provided with 5 bristles and a thin hair, the bristles being

short but fairly thick; in the new species there are some weak hairs instead (text-fig. 114, VIII. st.).

♀. The seventh sternite of the ♀ bears on each side a row of 12 or 13 bristles and about 6 small bristles in front of the row. The apex of this sternite (in lateral aspect) is truncate, the margin being very slightly excurved centrally. The eighth tergite has a cluster of 5 or 6 bristles below the stigma and about 15 bristles at, and near, the ventral and apical margins. As in the ♀ of *C. tesquorum*, there are two long antepygial bristles on each side, not accompanied by a third stout bristle, and the bristles of the anal sternite stand far removed from the base in a dense cluster occupying the apical two-fifths of the sternite.

One pair from Yu-lin-fu, Shensi, 4000 ft., taken off *Citellus mongolicus*.

7. *CERATOPHYLLUS FAMULUS*, sp. n. (Text-fig. 115.)

♀. Closely resembling the preceding species, but the bristles on the body and legs are more numerous.

Head.—Frons moderately curved, slanting. The tubercle small, placed a little nearer to the central sensory organ (pale dot) than to the oral corner. In front of the well-developed eye there is a row of three bristles, the upper one being placed a little lower than the centre of the eye and the second being nearer to the upper than to the lower bristle. Between the upper bristle and the antennal groove there are several minute hairs. The occiput has above the antennal groove one long bristle and about 14 minute hairs. The subapical row of bristles of the occiput contains on each side five or six, of which the lowest is the largest, being separated from the next bristle by a wide interspace. The bristles of the second antennal segment are long, ten of them reaching the apex of the club or beyond. The rostrum extends beyond the base of the fore femur, the apex of the fourth segment being on a level with the base of the trochanter. The maxillary palpus reaches to the base of the fourth segment of the rostrum.

Thorax.—The pronotal comb consists of 20 spines. The meso- and metanotum have each two rows of bristles, the second row containing 11 or 12 and the anterior one 15, on the two sides together. The mesonotum has about six and the metanotum two or three additional bristles on the back. The mesopleura have about five long bristles and anteriorly several thin hairs. The metepimerum bears six bristles (2, 3, 1). There are two short apical spines on each side of the metanotum.

Abdomen.—The tergites have all two rows of bristles, with one or two additional bristles on the back; tergites I to IV bearing, moreover, some apical spines. The stigmata are placed above the first bristle of the posterior row, but far in front of it. The first sternite bears a pair of ventral bristles, and no lateral bristles or only one. The sternites of segments III to VI have on the two sides together a postmedian row of 8 bristles and a few additional small bristles in front of the row. The seventh segment, however,

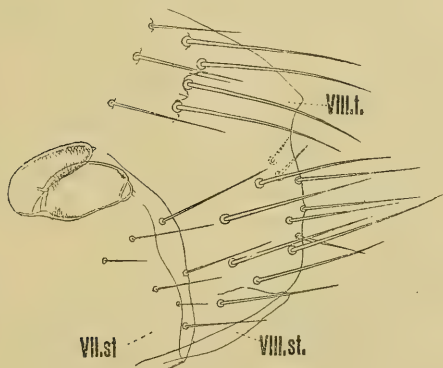
has ten long bristles in a row and no less than about 30 additional bristles, on the two sides together. There are two long antepygial bristles on a double cone.

Legs.—The fore femur has on the outer surface about 11 lateral bristles arranged in two irregular rows and on the inside a row of five lateral bristles. The mid and hind femora have outside one or two lateral bristles, and inside a row of 9 or 10 and 12 or 13 respectively. The dorsal and apical bristles of the tibiae and the apical ones of the tarsal segments are stout. The hind tibia has 10 lateral bristles on the outside and 5 to 7 on the inside. The longest apical bristle of the mid tibia almost reaches to the apex of the second tarsal segment. The second hind-tarsal segment has two apical bristles which extend to the apex of the third segment or beyond. The fifth tarsal segment has five lateral pairs of bristles. The measurements of the tarsal segments are as follows:—

Mid tarsus : 20, 21, 14, 9, 22.

Hind tarsus : 53, 34, 21, 12, 24.

Text-fig. 115.



Abdominal segments VII & VIII and receptaculum seminis of
Ceratophyllus fumulus ♀.

Molified segments.—♀. The apical margin of the seventh sternite (text-fig. 115, VII. st.) is slanting and slightly undulating. The eighth tergite bears two rows of bristles beneath the stigma and about 16 bristles on the lower half. The apical margin of this tergite is rounded-truncate, with the upper angle distinctly produced. The ninth sternite (not drawn) bears several small bristles. The stylet, which has the shape of a champagne bottle, is twice as long as it is broad. The head of the receptaculum seminis is about as long as the tail.

Length (of mounted specimens) 2.4 to 2.6 mm.

Two females; locality and host as in species 3 and 4.

8. CERATOPHYLLUS EUTELES, sp. n. (Text-fig. 116.)

♀. This is one of the species in which the first pair of bristles of the fifth segment of all the tarsi is shifted on to the ventral surface, being placed almost in between the second pair. The species may be recognised by the absence of bristles from the first abdominal sternite, the shortness of the bristles on the tarsi, the paucity of bristles on the femora, &c.

Head.—The frontal tubercle is placed nearer to the central sensory organ (pale dot) than to the oral angle. The eye is well developed and pigmented. There is a row of three long bristles before the eye, the uppermost bristle being a little lower than the centre of the eye. In front of this bristle there are one or two small bristles and usually a third further upwards nearer the antennal groove. The occiput bears a large bristle above the centre of the antennal groove, a small bristle further frontad and another small one further dorsad. The subapical row of bristles of the occiput consists on each side of 6 bristles, of which the ventral one is large. The interspace between this bristle and the next is twice the size of the interspace between the second and third bristles of that row. Five of the bristles of the second antennal segment are prolonged, two of them nearly reaching to the apex of the club. The rostrum extends to the apex of the coxa, its fifth segment being more than twice the length of the fourth. The maxillary palpus reaches to the apex of the fourth segment of the rostrum, the proportional lengths of its segments being 17, 15, 12, 19.

Thorax.—The pronotal comb consists of 18 spines. The meso- and metanotum bear each two rows of bristles and a few additional dorsal bristles representing a third row. The mesopleura have 8 bristles and some additional short stout hairs. The metepimerum bears 6 bristles (2, 3, 1). The metanotum has one apical spine on each side.

Abdomen.—The tergites bear each two rows of bristles as follows (the first number being that of the anterior row): 8 or 9, 9—8 to 10, 12—8 to 10, 12—7 to 9, 12 or 13—5 or 9, 12 or 13—5 or 8, 11 or 12—3 or 4, 9 or 10. The first sternite has no bristles at all. The sternites of segments III to VI have on each side three bristles, and that of segment VII bears four bristles with an additional bristle in front of the row. There are three antepygial bristles, the middle one being twice the length of the upper and one-fifth longer than the lower.

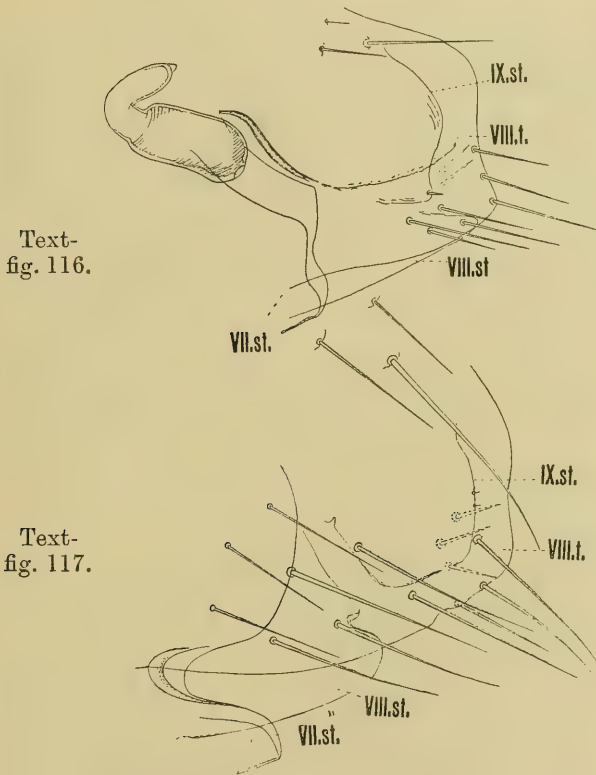
Legs.—The fore femur has two bristles on the outer surface, and one on the inner, apart from a ventral subapical bristle. The mid and hind femora have only the subapical ventral bristle on the outside, and on the inside a small lateral bristle and a small ventral subapical one. The hind tibia has a row of 8 lateral bristles on the outside and two or three bristles on the inner. The first and second hind-tarsal segments are long and slender and the bristles of the tarsi short. The longest apical bristle of the second hind-tarsal segment is one-third shorter than the third segment. The fifth segment is rather short in all the tarsi and bears

ventrally at the apex two short and fairly slender bristles, which are placed far apart. The first lateral pair of this segment stands nearly in between the second pair. The measurements of the tarsi are:—

Mid tarsus: 26, 23, 15, 9, 20.

Hind tarsus: 54, 34, 23, 13, 21.

Modified segments.—♀. The seventh sternite (text-fig. 116) rather strongly narrows apically, being truncate-sinuate in two specimens as shown in the figure, while in a third the apical margin



Text-fig. 116.—Abdominal segments VII & VIII and receptaculum seminis of *Ceratophyllus euteles* ♀.

Text-fig. 117.—Abdominal segments VII & VIII of *Ceratophyllus phaeopis*.

is more slanting and hence the ventral angle (in side view) more pointed. The eighth tergite (VIII. t.) bears one long and two short bristles below the stigma and 7 to 10 bristles in the ventral half, three of which are placed at the edge above the ventral angle.

The apical margin of this tergite is gently incurved, its upper angle being rounded, and the lower one projecting and being almost pointed. The ninth sternite (IX. st.) bears one short but rather stout bristle at its lower corner. The receptaculum seminis has an elongate head, which is longer than the tail.

Length (mounted specimens) 2.4 to 2.7 mm.

Three females from 23 miles S.E. of Ta-t sien-lu, 7500 ft., off *Sciurotamias davidianus consobrinus* M.-Edw.; Omi-shan, Szechuen, 9500 ft., off the same host and off *Tamiodops swinhoei* M.-Edw.

9. CERATOPHYLLUS PHEOPIS, sp. n. (Text-fig. 117.)

♀. This species, of which we have only one female, is easily recognised by the very feebly pigmented eye, the very short bristles of the antenna, and the deeply sinuate seventh abdominal sternite.

Head.—The frons is very slanting. The frontal tubercle stands about halfway between the oral corner and the central sensory organ (pale spot), the distance from the tubercle to the oral angle being about equal to the diameter of the eye. There are three long bristles in front of the eye, the uppermost being placed near the antennal groove, the interspace between this bristle and the second being nearly twice as large as the interspace between the second and third bristles. In front of the lower bristle there is one small bristle, several minute hairs being placed in between the two other bristles. The occiput bears one bristle above the antennal groove, and a subapical row of 5 (on each side), the most ventral of them being long and strong. The bristles of the second segment of the antenna are quite minute. The rostrum reaches to the apex of the coxa, the last segment being half as long again as the fourth. The eye is feebly pigmented, excepting the anterior and posterior edges. It appears deeply excised at a certain focus.

Thorax.—The comb of the pronotum consists of 18 spines, the most ventral one of one side being very small. The meso- and metanota bear each two rows of bristles. The mesopleura have 5 or 6 bristles and the metepimerum 8 (4, 3, 1). The metanotum has also 2 apical spines on each side.

Abdomen.—The tergites bear two rows of bristles, the anterior row containing but a small number of them, the numbers in the two rows being 7 and 14 on the fourth tergite on the two sides together. The stigmata are placed dorsally to and in front of the ventral bristle of the second row. There are three antepygial bristles, the lower one being but little shorter than the central bristle, while the upper one is about one-third the length of the latter. The basal sternite has on each side a patch of four lateral bristles and ventrally one bristle. The numbers of bristles of the sternites of segments III to VII are on the two sides together (the first number giving the bristles placed in front of the row) 4, 11—3, 11—2, 8—0, 10. Tergites I and II bear an apical spine on each side.

Legs.—The hind femur bears on the outside one subapical ventral bristle and one lateral subbasal one, and on the inside a row of 5 or 6 bristles. The hind tibia has a single lateral row of 7 or 8 bristles on the outside and a row of 3 or 4 on the inside. The tarsi are slender. The second hind-tarsal segment bears an apical bristle which reaches beyond the apex of the fourth segment and another which extends beyond the apex of the third. The fifth segment bears in all the tarsi five pairs of lateral bristles. The measurements of the tarsi are:—

Mid tarsus: 29, 25, 15, 11, 24.

Hind tarsus: 58, 38, 23, 13, 27.

Modified segments.—♀. The seventh sternite (text-fig. 117, VII. st.) bears a deep sinus and is strengthened proximally to the sinus by a curved band-like incrassation. The eighth tergite has three bristles below the stigma, arranged in a triangle. The bristles on the lower half of the segment are few in number. The apical margin is rounded and, above the marginal bristles, slightly incurved. The ninth sternite (IX. st.) bears a few minute hairs. The stylet is short and bottle-shaped, being twice as long as it is broad near the base. Its apical bristle is a little smaller than the most ventral one of the seventh tergite. The receptacle stands on end in our only specimen, and for that reason its shape cannot well be made out. The head appears to be round, and much shorter than the tail.

Length (of mounted and extended specimen) 3.2 mm.

One female from 23 miles S.E. of Ta-tsien-lu, 7500 ft., off *Sciurotamias davidianus consobrinus* M.-Edw.

10. AMPHIPSYLLA CASIS, sp. n. (Text-figs. 118, 119.)

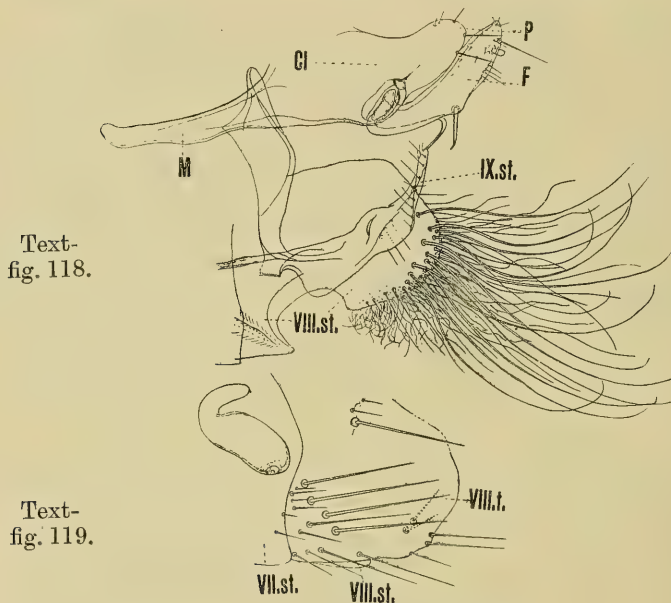
♂ ♀. The nearest ally of this species is *A. dæa* Dampf (1910) from Turkestan. The detailed description which A. Dampf gave applies almost verbally to the present flea, except for the points mentioned below, and the beautiful figures published by that author of the head of the ♂ of *dæa* and the last segments of the ♀ agree also equally well with the new species. As in some other instances mentioned in this paper, we suspect that we are dealing with a Chinese (or East-Asiatic) representative of *dæa*.

Both sexes have, on the whole, less bristles than *A. dæa*. The sternum of the metathorax bears only one long bristle, which is occasionally accompanied by a minute hair. The stigmata of the abdomen are situated between the second and third bristle of the posterior row, not above the third, on the seventh segment sometimes below the second bristle.

The epimerum of the metathorax bears 7 bristles only (2, 3, 2).

The anterior row of bristles on the first abdominal tergite contains on the two sides together about 8 bristles, and the posterior row 10, the numbers of bristles in the posterior rows on the other tergites being (also on the two sides together) 18, 17, 16, 16, 17, 16.

The bristles on the sternites II to VII number on the two sides together 2, 8, 7, 7, 8, 9, there being no short bristles in front of the row. The eighth tergite is similar to the figure given by Dampf of that segment of *A. dæa*, but the bristles near the upper edge are more numerous and those on the side less numerous. The eighth sternite (text-fig. 118) is more densely hairy than in *A. dæa*, the hairs at the inner side of the margin being very numerous, thin and more or less wavy, while those on the outer side are longer and thicker, the longest hairs being longer than the eighth sternite. The clasper (Cl) is less broad than in Dampf's figure and its upper margin more distinctly incurved,



Text-fig. 118.—Clasping organs of *Amphipsylla casis* ♂.

Text-fig. 119.—Abdominal segments VII & VIII and receptaculum seminis of *Amphipsylla casis* ♀.

the portion beyond the insertion of the movable process being consequently slenderer than in *A. dæa*. The finger itself (F) bears the same armature as in *A. dæa*, but is altogether slenderer, and at the apex distinctly narrowed, not widened as in *A. dæa*. The ninth sternite (IX. st.) is not at all the same as in *A. dæa*. The apical third of the horizontal arm is very narrow, its top is more strongly chitinized, and bears a short, proximally thick, terminal bristle on each side; the distribution of the fine hairs may be gathered from the figure.

The bristles of the abdomen and legs are more numerous than

in the ♂, their number coming within the limits of variation of *dæa* as given by Dampf.

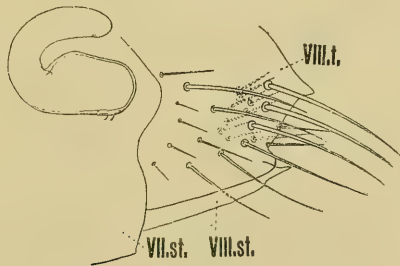
The receptaculum seminis differs from Dampf's figure of that organ of *A. dæa* in having a distinctly shorter tail.

One male and two females from Yu-lin-fu, Shensi, 4000 ft., taken off *Myospalax fontanieri*.

11. *NEOPSYLLA COMPAR*, sp. n. (Text-fig. 120.)

♀. Very similar to *N. bidentatiformis* Wagn. (1893), from which it differs chiefly in the following points:—The pronotum bears a row of 8 small bristles in front of the postmedial row of bristles on the two sides together. The seventh abdominal sternite is a little more deeply sinuate (lateral aspect) and its bristles are rather stronger. The hind coxa, which bears in *bidentatiformis* a large number of slender hairs on the inner side along the anterior edge, has a patch of short spines besides many hairs. The dorsal bristles of the hind tibia are thinner in *compar* than in *bidentatiformis*, and the hind tibia bears on the outer surface two rows of only 9 instead of 11 bristles, the rows, moreover, being separated from the ventral bristles by a wide interspace without bristles,

Text-fig. 120.



Abdominal segments VII & VIII and receptaculum seminis of
Neopsylla compar ♀.

while in *bidentatiformis* the interspace bears several additional bristles. The bristles at the hinder side of the first segment of the mid and hind tarsi are thicker than the proximal bristles of the anterior edge of the segment in Wagner's species, there being three such bristles in the mid tarsus and five in the hind tarsus, apart from the apical bristle. In the new species the bristles of these tarsal segments are practically the same on the two sides. Moreover, there are 10 or 11 bristles on the outer surface of the first hind-tarsal segment of *bidentatiformis* and only 8 or 9 in *compar*. The second mid-tarsal segment is a little shorter in *compar*, the measurements of the first and second segments being in *compar* 28 and 19, and in *bidentatiformis* 28 and 23. The eighth tergite has in *compar* on the outer surface a marginal row of 6 or

7 bristles, and near these bristles about 8 more, of which 2 are long (text-fig. 120). In *bidentatiformis* the marginal row contains 9 bristles and there are about 15 lateral ones, of which at least 4 are long. In both species is the head of the receptaculum seminis half as long again as broad, and the tail half as long again as the head. The two insects do not present any appreciable difference in this organ.

One female from Yu-lin-fu, Shensi, 4000 ft., taken off *Dignus sowerbyi*.

12. *NEOPSYLLA ALIENA*, sp. n. (Text-figs. 121, 122.)

♂ ♀. Differs from true *Neopsylla* in the hind coxa bearing a patch of short spines on the inner surface, and in the fifth segment bearing in all the tarsi five lateral bristles. Both characters are of great interest. The development of bristles into short spines on the hind coxa is met with in many genera of fleas, but not in *Ceratophyllus* proper, not in *Neopsylla*, *Ctenophthalmus*, and *Palaeopsylla*, except the two new *Neopsylla* here described. A survey of the genera which bear coxal spines renders it evident that such spines have been acquired independently in many instances and do not necessarily indicate close affinity. A species with spines may be more nearly related to one without them than to another which also bears coxal spines.

Five lateral bristles on the fifth tarsal segments are an ancestral character for fleas, the segment with more than five such bristles, or with the proximal pair shifted on to the ventral surface, or with less than five pairs being more recent modifications. The five pairs are normal for *Ceratophyllus*, while the species of *Neopsylla*, *Palaeopsylla*, *Ctenophthalmus*, and *Amphipsylla* have either five pairs in the hind tarsus with the first pair placed in between the second, or possess only four pairs. The present new species, therefore, connects that group of genera with normal *Ceratophyllus*. But the interest of the species does not end there. We find that the fifth tarsal segment of one hind leg has in both our females on one side four and on the other five bristles, while the segment has five on both sides in the other hind leg. In two of three males, both hind legs have five bristles on both sides of the fifth tarsal segment, whereas in a third male this segment has only four pairs of bristles. In all three instances where the number of bristles is reduced, it is the proximal pair, or a bristle of the proximal pair, which is absent. This appears to be decisive evidence that also in the allied species which have only four pairs of lateral bristles on the fifth hind-tarsal segment it is the first pair which has been lost.

Head.—Evenly rounded, the frontal outline vertical in the ♂, more slanting in the ♀. Eye indicated by a narrow oblique bar. Two genal spines, which cross each other as in many of the species of this relationship, the outer spine being short and broad and the lower one long and pointed. The genal lobe itself is narrower at its base than in the centre, being sole-shaped. The frontal

tubercle is small. The frons bears two rows of bristles, the anterior row containing in the ♂ 6 to 9 and in the ♀ 5 to 6 bristles, the posterior row 3 long ones, in between which there are a few minute hairs. The occiput has also two rows, an anterior one of 5 or 6 and a posterior one of 7 on each side, there being along the antennal groove a number of small hairs, in the ♂ an irregular row of about 18, and in the ♀ a patch of about 6 below the last bristle of the posterior row and two or three hairs further forward. The proportional measurements of the segments of the maxillary palpus are 12, 10, 8, 16. The maxilla is long, reaching to the apex of the third or base of the fourth segment of the rostrum. The latter is one-third to one-fourth short of the apex of the fore coxa; the fifth segment is more than twice the length of the fourth. The antennal groove is continued to the vertex in both sexes. The second segment of the antenna bears in the ♀ three bristles, which extend beyond the apex of the club.

Thorax.—The pronotum bears a comb of 16 spines and a row of 15 or 16 bristles on the two sides together. There are on the mesonotum a postmedian row of 14 long bristles, an anterior row (sometimes double laterally) of 17 to 19, and a basal row of rather long thin hairs, a few additional, short, dorsal bristles being placed in the ♂ in front of the anterior row; before the apex of the mesonotum there are 6 bristle-like spines on the underside. The sides of the mesosternite bear 9 bristles. The metatergite has a posterior row of 14 or 15 bristles, and an anterior row of 12 or 13. The metepisternum bears 3 or 4 bristles, and the metepimerum 12 to 14 (4 to 6, 5, 2 or 3).

Abdomen.—The tergites I to VII bear each two rows of bristles, the posterior row containing 18; the anterior row is reduced on the posterior segments of the ♂ to a few bristles. The stigma stands within the posterior row between the first and second bristle. The basal sternite has the usual pair of ventral bristles and on each lateral surface 2 or 3 more bristles. The sternites III to VII bear a row of 6 to 8 bristles in the ♂ and 10 in the ♀, there being also several (about 6 to 8) small bristles in front of the row. On the seventh segment the row contains 14 to 16 bristles in the ♀ and 8 in the ♂. Three antepygidial bristles, in ♂ the central one about three times the length of the others, in the ♀ not quite thrice the length of the upper one and less than twice the length of the lower one.

Legs.—The hind coxa bears a patch of about 18 spines on the inner surface. The hind femur has two subapical ventral bristles on the outside and one on the inside, there being also one small lateral bristle on the inside at the basal fourth. The outer dorsal bristles on the mid and hind tibiæ are strong and all of nearly even size, there being 10 or 11 such bristles inclusive of the apical ones, and four long dorsal bristles on the inner side of the edge. The lateral bristles are 5 or 6 in number and form one row. The bristles at the hinder side of the first mid- and hind-tarsal segments are likewise strong and not quite so long as the corresponding

bristles of the tibia, the first mid-tarsal segment bearing 4 or 5 such bristles and the hind-tarsal one 5 or 6. The bristles on the anterior side of the first tarsal segments are much less numerous. The two longest apical bristles of the hind tibia reach far beyond the apex of the first tarsal joint, the longest of this segment extends beyond the tip of the second segment, the longest of the second segment to the middle of the fourth. The proportions of the tarsal segments are:—

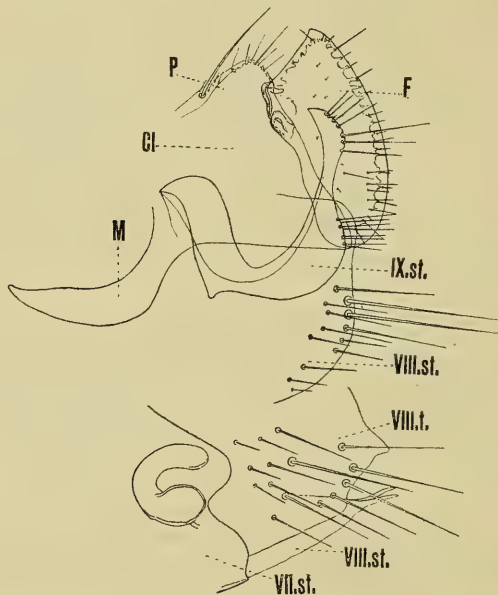
Fore tarsus: ♂. 11, 10, 10, 8, 17; ♀. 13, 12, 11, 9, 19.

Mid tarsus: ♂. 22, 18, 13, 9, 19; ♀. 28, 22, 15, 10, 21.

Hind tarsus: ♂. 33, 27, 18, 12, 19; ♀. 42, 32, 21, 13, 22.

The fifth segment has in all the tarsi five pairs of lateral bristles, occasionally the basal pair or one bristle of it being absent from the hind tarsus.

Text-
fig. 121.



Text-
fig. 122.

Text-fig. 121.—Clasping organs of *Neopsylla aliena* ♂.

Text-fig. 122.—Abdominal segments VII & VIII and receptaculum seminis of *Neopsylla aliena* ♀.

Modified segments.—♂. The eighth sternite is broad, with the apex almost evenly rounded in side view. It bears ventrally on each side 14 to 16 bristles, of which two of the distal ones are very long. The main body of the clasper (Cl) is almost square (text-fig. 121). Its upper distal corner is rounded off and not produced into a narrow process. There are a number of small bristles at this corner, but no bristle near the insertion of the

movable process. The latter (F) is large, triangular, with the distal side rounded and longest and the upper proximal side shortest, the larger portion of the process lying from the point of insertion downwards. The distal margin of this finger bears numerous small bristles, which are nearly evenly distributed, one below the apex being noticeable by its somewhat larger size. The manubrium (M) is curved and widest in the centre, being canoe-shaped. The ninth sternite has a broad vertical arm, the proximal portion of the horizontal arm also being broad. The distal portion is at first narrow and then widens again, the apex being curved upwards and ventrally furnished with seven pairs of bristles (IX. st.).—♀. The seventh sternite (text-fig. 122) is almost gradually narrowed in lateral view and divided by a nearly central apical sinus into a rounded upper lobe and a broader and less rounded ventral lobe. The eighth tergite bears 3 or 4 bristles above the stigma and several smaller ones proximally to them. There are no bristles below the stigma, but the lower half of the segment has 6 or 7 strong bristles along the edge, and 1 to 3 large ones on the side; proximally to these lateral bristles there are about 6 to 8 smaller ones. At and near the apical edge, on the inner surface, there are two rows of bristles, 4 or 5 at the edge and 5 proximally to them. The upper apical angle of the segment is produced into a prominent point. The eighth sternite bears no bristles and ends on each side in a long slender point. The tail of the receptaculum seminis is about twice as long as the head of the same.

Three males and two females from Yu-lin-fu, Shensi, 4000 ft., taken off *Myospalax fontanieri*.

STENOPONIA, gen. nov.

♂ ♀. Similar to *Hystriehopsylla* Tasch. (1880), but differs in very essential characters as follows:—

The labial palpus consists of only one segment instead of five and does not extend much beyond the apex of the maxilla. The genal process is narrow and short, and does not reach further backwards than the uppermost spine of the genal comb. The club of the antenna is short in both sexes, being but little longer in the ♂ than in the ♀. The sensory plate of the ninth abdominal tergite is more convex than in *Hystriehopsylla*. The first pair of bristles of the fifth tarsal segment is placed in between the second pair in all the tarsi. The ♀ has only one receptaculum seminis instead of two.

Type: *tripectinata* Tiraboschi (1902), described as *Hystriehopsylla*.

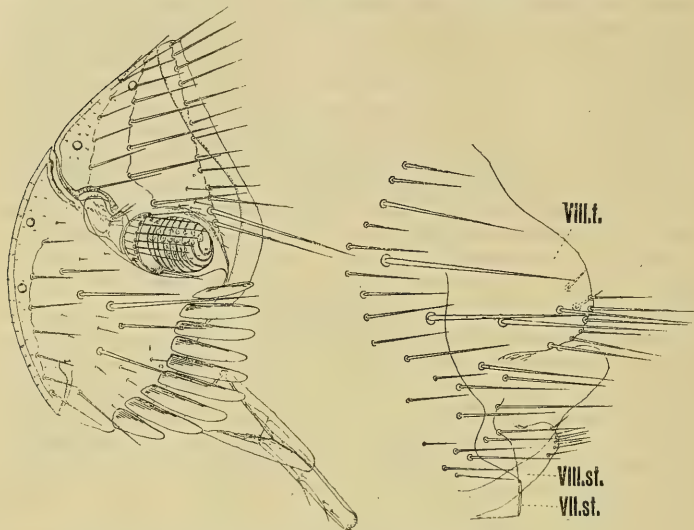
13. STENOPONIA CÆLESTIS, sp. n. (Text-figs. 123, 124.)

♀. Similar to *S. tripectinata* Tirab. (1902), but at once distinguished by the different shape of the head. In *tripectinata* the distance from the frontal corner to the first spine of the genal

comb is about the same as the distance from this spine to the last spine of the comb, whereas in the new species the former distance is less than half the latter.

Text-fig. 123.

Text-fig. 124.

Text-fig. 123.—Head of *Stenoponia caelestis* ♀*.Text-fig. 124.—Abdominal segments VII & VIII of *S. caelestis* ♀.

Head.—The genal process, which is visible above the last spine (text-fig. 123), is much broader than in *tripectinata*, and the rostrum is longer than in that species. The second segment of the antenna has two rows of bristles in both species. The genal comb consists of nine spines.

Thorax.—The thorax is similar to that of *tripectinata*.

The pronotal comb consists of 35 spines.

Abdomen.—The tergites have only two rows of bristles each, only segments I, II, and III having an incomplete third row, while in *tripectinata* all the tergites have 3 or 4 rows. There are 4 antepygial bristles on each side. The comb of the first tergite contains 31 spines on the two sides together.

Legs.—The bristles of the legs are shorter, especially those of the hind tarsus, and also not so thin at the tip. The longest apical bristle of the first hind-tarsal segment reaches only to the subapical notch of the second segment, and the longest bristle of the second segment scarcely extends to the apex of the third.

Modified segments.—♀. As these segments are represented by text-fig. 124, we need only point out some characters in which they differ from the segments of *tripectinata*. The lobe

* The lateral pale dot of the occiput is omitted.

below the sinus of the seventh sternite (VII. st.) is narrower in *tripectinata*, and the lobe above the sinus longer than the lower lobe, the sinus therefore being much deeper in that species. The eighth tergite is divided by an apical incision into a broad setose upper lobe and a narrower and naked lower lobe in both species. The upper lobe, however, bears more bristles in *tripectinata* both on the outer and inner surfaces, and the bristles placed further proximad on the eighth tergite are also more numerous in *tripectinata*. The eighth sternite, on the contrary, has more bristles at the apex in the new species.

Length (mounted specimen, somewhat contracted) 3.5 mm.

One female from 23 miles S.E. of Ta-t sien-lu, 7500 ft., off *Sciurotamias davidianus consobrinus* M.-Edw.

20. Contributions to the Anatomy of the Anura. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received December 28, 1910: Read March 7, 1911.]

(Text-figures 125-133.)

I. SOME NOTES UPON THE FROG *MEGALOPHRYS* (*LEPTOBRACHIUM*) *FEÆ*.

Of this species* living examples have been recently, and are at the moment, exhibited in the Society's Gardens. The Frog was later described by Mr. G. A. Boulenger† as of the genus *Leptobrachium*, but originally‡ referred to the genus *Megalophrys*, to which all the Pelobatidæ belonging to the former genera *Megalophrys*, *Xenophrys*, and *Leptobrachium* are now§ by him referred. In dealing with certain points in the anatomy of *M. feæ*, I shall have occasion to refer to the mutual likenesses and unlikenesses between this and other species of the family to which I have already paid some attention||.

The external characters have been so fully described by Mr. Boulenger in the several papers quoted below, that little remains to be said under this heading. There is, however, one point to which I may refer. In dealing with *Xenophrys monticola* and other forms, I have described¶ and figured a glandular patch upon the thigh which is very characteristic of these Frogs. I can find no trace of this structure in *Megalophrys feæ*; and it is thus

* The specimens were, as I understand, identified by Mr. G. A. Boulenger.

† Ann. Mus. Civ. Genova, vol. vii. 1889, p. 750.

‡ *Ibid.* vol. iv. 1887, p. 512. For other references see Mr. Boulenger's paper in the P. Z. S. quoted below.

§ P. Z. S. 1908, p. 407.

|| P. Z. S. 1907, p. 324, and *ibid.* 1907, p. 871. The latter paper deals with *Megalophrys montana*, "*Xenophrys monticola*," "*Leptobrachium hasseltii*," and, incidentally, with *Megalophrys nasuta*, which is more fully described in the former paper.

¶ P. Z. S. 1907, p. 879, text-fig. 230.

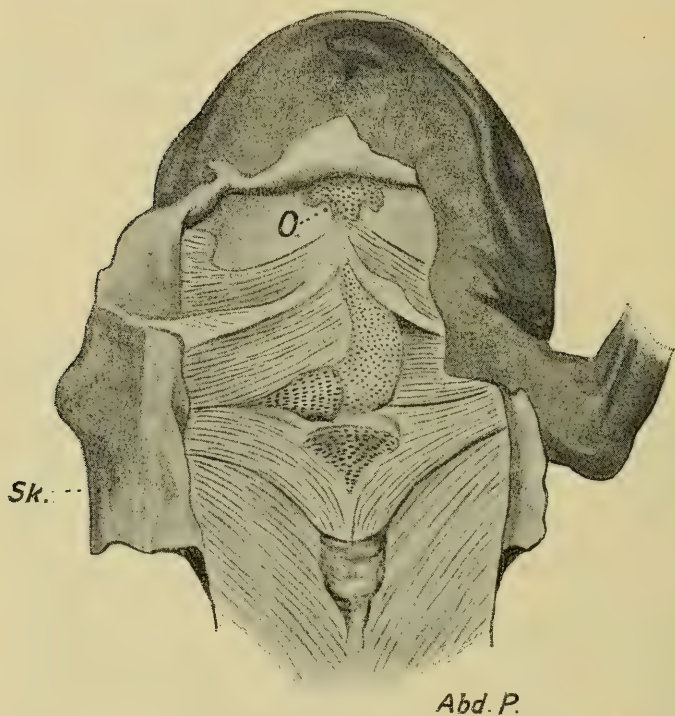
evidently not a distinguishing feature of the genus, as opposed to *Pelobates*, as I had been disposed to think.

I now direct attention to other points in the anatomy of this species, and more especially to those which are already known to be of systematic importance. This, indeed, has been my object rather than to attempt a more comprehensive anatomical account.

§ *Sternum.*

In considering the mutual affinities of four species of *Pelobatidæ* described by me in a former paper*, I had laid some stress

Text-fig. 125.



Ventral view of anterior part of the body of *Megalophrys feæ* partially dissected.

Sk. Skin reflected. *Abd. P.* Pectoralis abdominalis. *O.* Omosternum.

The cartilaginous right overlapping epicoracoid is dotted; the bony coracoid and shaft of sternum are marked by short lines.

upon the proportions visible in the total length of the body on the one hand, and of the sternum and sternal region on the other.

* P. Z. S. 1907, p. 891.

The measurements which I have just made upon *Megalophrys feæ* confirm the value of the results which I obtained from the former series of measurements. Of *Megalophrys feæ* I ascertained the following measurements:—length of body from snout to cloacal aperture 95 mm. ; length of sternal region from anterior

Text-fig. 126.

Sternum of *Megalophrys feæ* from the ventral surface.

O. Omosternum. X. Xiphisternum.

Between the omosternum and the shaft of the sternum is seen the right, overlapping, epicoracoid.

end of omosternum to posterior end of sternum 30 mm. ; length of sternum proper 17 mm. Considering the body-length as 10, the other measurements will be respectively 3.2 and 1.8. The proportions therefore are, it will be observed, exactly as in the species *Leptobrachium hasseltii*. In a second specimen the

proportions were the same, the Frog being about 1.5–2 mm. longer with a corresponding increase of length of from .5–1 mm. in the sternal measurements.

It is, as is well known, the general rule among the Arciferous Batrachia Salientia that the right epicoracoidal cartilage should overlap the left ventrally. This was the case in three out of the four examples of *Megalophrys feæ* which I have had the opportunity of examining (see text-fig. 125, p. 394). In the fourth, however, the converse condition occurred. It may be that this individual is of a different species; and yet I cannot find from a study of Mr. Boulenger's table of classification * any grounds for identifying this individual with other species described by him. It is, however, rather different in appearance from the other Frogs; its build is more slender, the pelvic width is less, and the dorsal depression is much deeper and with a more arched upper bordering ridge. Other depressions upon the head are also more marked. I could not, however, detect any other external differences. All the four specimens, I should observe, are males.

In view of the fact that the *omosternum* is already known to differ among the species of *Megalophrys* (contrast, for example, *M. montana* and *M. nasuta*), it is important to note the condition in *Megalophrys feæ*. In this species (see text-fig. 126) it is, in fact, quite as well-developed as in *Megalophrys nasuta*, from which, however, it differs in various details. Its total length is 8 mm., which represents a size proportionately equal to, or not very different from, that of *Megalophrys nasuta*. The epicoracoids are firmly attached to the basal portion of the omosternum, which shows a trace of its double origin (? from the two epicoracoids) in that it is divided longitudinally by a white fibrous seam. This part of the omosternum is, in fact, precisely as is figured by W. K. Parker † in *Pseudis*. In addition to this there is a distal piece which is single and not divided longitudinally, but which is divided off by a seam from the basal portion of the omosternum. This piece is cheese-cutter-shaped, as shown in text-fig. 126.

§ *The Hyoid and its Musculature.*

The *hyoid* cartilages and bones, as I have already pointed out, present some differences among the various species of *Megalophrys* (s. l.). I have therefore attempted a careful study of this portion of the skeleton in *Megalophrys feæ*. The basal cartilage of the hyoid has the usual broad form found in the allies of this species; of this the *processus anteriores* are bowed inwards anteriorly almost to meet in front of the exit from the hyoid region of the hyoglossal muscle. This condition of the processes in question has apparently, as I have already pointed out, some systematic importance. The hyoglossal sinus, thus nearly converted into a

* P. Z. S. 1908, p. 410.

† 'A Monograph of the Shoulder-Girdle,' Ray Soc. Publ. 1868, pl. vi: fig. 7.

foramen, is of much greater diameter than the hyoglossal muscle which passes through it. The inconvenience which might thus result is obviated by the existence posteriorly of a tough translucent membrane, which largely occupies the hinder part of the sinus by stretching across it. It has a clean semicircular edge in front over which the muscle plays. I have been unable to find any anterior cornua of the hyoid, which appears to be absent, at any rate as a discrete cartilage, in this group of Frogs. But the lateral foramina are present and correspond, as I imagine, to similar foramina in *Pelodytes punctatus*, the development of which has been worked out by Ridewood*. In *Megalophrys feæ* they transmit in the same way the glossopharyngeal nerves, than which they are only just larger. The strongly ossified thyrohyals have the usual elongated hourglass shape. The distal cartilaginous epiphysis of each of these bones has very much the shape and direction that it has in *Xenophrys monticola*, to my figure of which I refer below †.

The musculature of the hyoid does not appear to me to present any particular features of interest as compared with allied forms. The *hyoglossus* did not show the twisted rope-like strands that I have observed and described in allied forms. Each muscle arose solely from the inner and lower border of the thyrohyal bone, and not at all from the flat surface of that bone.

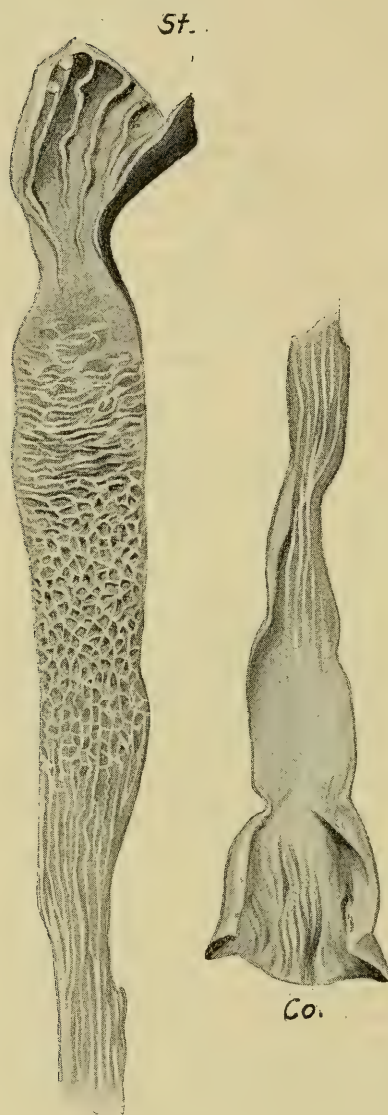
§ Alimentary Canal.

The accompanying drawing (text-fig. 127, p. 398) of the alimentary canal of *Megalophrys feæ* may be compared with that of *Breviceps* upon a later page (p. 407). The stomach of the *Megalophrys* is longitudinally ridged by thick ridges, of which there are eight in the middle of that organ. Of these only three survive until the opening of the stomach into the duodenum; the others die away and cease to be ridges. The *intestinal tract* measures 104 mm., and is to be divided into a very short duodenum, a wider ensuing region, and then a narrower ileum which opens into the large intestine. The regions are, in fact, quite as in *Breviceps*. The length of the three different regions of the small intestine are 6, 42, and 57 mm. respectively. Although it will be observed that these measurements do not tally exactly with the total length of the small intestine, it will be noted that they are only divergent by 1 mm. As the measurements of the different regions of this gut were made quite independently and without any concurrent reference to the total length of the small intestine, I leave them at the figures which I have given. It will be observed that these proportions are very different from those exhibited by *Breviceps*. There are also certain differences in the ridges which

* "On the Structure and Development of the Hypobranchial Skeleton of the Parsley Frog (*Pelodytes punctatus*)," P. Z. S. 1897, p. 577.

† P. Z. S. 1907, p. 898, text-fig. 238.

Text-fig. 127.



The alimentary tract of *Megalophrys feæ* from the middle of the stomach to the middle of the colon laid open and divided into two portions, an anterior (to the left) and a posterior (to the right of the figure).

St. Stomach. Co. Colon.

line the gut. But the general plan is the same. The first region, which is so very short, is marked off from the stomach by a sudden diminution in the thickness of its walls. The lining-membrane is at first smooth and is later covered by ridges forming a reticulum. These gradually become the circular folds like those of *Breviceps*; but the region of the gut where the circular folds occur is very limited and not more than 10 mm. long. The terminal and narrower portion of the gut is marked by about ten longitudinal folds, the transition between which and the transverse folds is a network.

These folds are at first permanent and cannot be removed by stretching the gut; later they exist, but can be removed by stretching. Finally, this region of the gut becomes smooth before its opening into the large intestine. The latter is at first smooth but later has longitudinally running folds.

The *liver* viewed from the ventral surface is seen to consist of a larger left lobe and a much smaller right lobe, between which the large gall-bladder is very obvious and extends back a good way beyond the edge of the liver into the abdominal cavity. Under the large left lobe lies a smaller lobe, which is of about the same size as the right lobe and is continuous with it under the pericardium and membrane of the gall-bladder.

Lying above the viscera the large *subvertebral lymph-space* is very obvious. Its relations to the body-wall and to adjacent viscera are as follows:—The sac is bifurcate in form and extends forward beyond the anterior end of the kidney, but not so far as to the anterior end of the ileum. The two bifurcations of the sac lie on either side of the ileum, and the sac therefore does not extend so far forward where it lies upon the iliac musculature as it does right and left of this region. It does not extend ventrally to the kidney, but separates this viscus dorsally from the dorsal body-wall. Posteriorly it overlies the bladder, which is firmly attached to its wall.

§ *Esophageal Muscle.*

This visceral skeletal muscle is so important and characteristic in *Megalophrys* and its allies that its consideration demands a section to itself. It is rather thin and does not overlap the kidney, which lies entirely posteriorly to it. It does, however, overlap the anterior part of the ileum. I have figured the muscle in *Megalophrys montana** as extending far back, in fact so that it overlaps the sacral vertebra transverse process at its comparatively narrow origin from the centrum. This was not the case with *Megalophrys feae*, where the muscle is therefore less extensive. It is, however, large when compared with that of Frogs of other families. It appears to differ but little in details from the muscle of *Megalophrys nasuta*†.

* P. Z. S. 1907, p. 886, text-fig. 233, m.

† Loc. cit. p. 876, text-fig. 229, b.

§ *The Larynx.*

I do not here figure the larynx of *Megalophrys feæ* because it agrees substantially with that of other Oriental Pelobatidæ figured elsewhere by myself*. There are, however, as I have shown in the memoir referred to, at least specific differences among the Pelobatidæ. I find that *Megalophrys feæ* agrees very closely with *Xenophrys monticola* and thus differs from *Leptobrachium hasseltii*. The hypopharyngeal processes of the cricoid cartilages are well developed and remain separate, *i. e.* are not united into a single bar. A delicate semicircular bronchial cartilage is quite obvious attached or close to the anterior extremity of the cricoid cartilage.

§ *Muscles of Ventral Surface.*

In removing the skin of the ventral surface in the pectoral and cephalic region the septa bounding the lymph-spaces in that region come into view. I have already figured these in *Xenophrys monticola*†, and the corresponding septa in *Megalophrys feæ* appear at first sight to be much the same. The posterior of the two is rather more chevron-shaped in the line of its attachment perhaps; but this may be a matter of varying tension. On the other hand, the same chevron line occurs in *Leptobrachium hasseltii*‡. In *Megalophrys feæ* the line of insertion of the wall of the subcutaneous lymph-sac does not extend obliquely downwards on to the pectoralis abdominalis as in *Leptobrachium*. There appears to be no invasion of this membrane by muscular fibres, and in this the present species agrees with the two just referred to.

The anterior wall of the pectoral or thoracic lymph-sac has been figured by myself as a single wall in the two species which are above referred to, and as arising from the edge (posterior) of the submaxillaris muscle. I find precisely the same origin in *Megalophrys feæ*; but there is in addition another membrane rising from the muscular surface behind this line which joins the first-named to be inserted in common with it on to the skin. This tent-like arrangement leads to the formation of an additional sac, which is obviously triangular in section. I may, perhaps, have missed something of the same kind in the other Megalophryid Frogs which I have examined. Examined microscopically, the two walls of membrane showed nothing but white fibrous connective-tissue; there was no trace whatever of any muscular invasion, and, indeed, the edge of the submaxillaris could be plainly seen to give off no fibres into the membrane. Inasmuch as I observed this double wall in four examples of the Frog, there can, I think, be little doubt of its being the normal arrangement.

A further exploration of this cavity shows that it is not a lymph-sac at all; it is the gular sac which is thus intruded

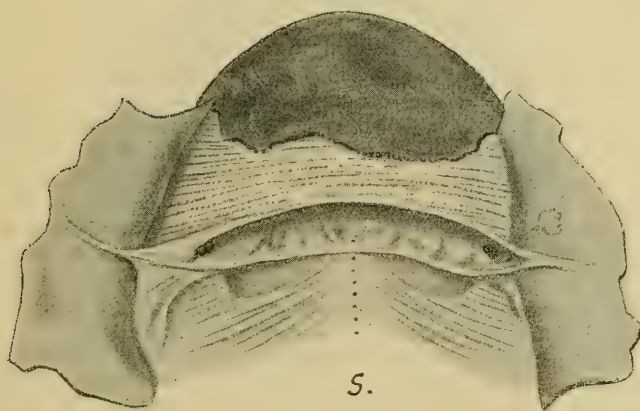
* P. Z. S. 1907, p. 898, text-fig. 238, p. 899, text-fig. 239, p. 902, text-fig. 240.

† P. Z. S. 1907, p. 882, text-fig. 231.

‡ *Loc. cit.* p. 881, text-fig. 232.

between two subcutaneous lymph-sacs. At each corner near to the angle of the jaw is the orifice into the mouth-cavity, through which a probe was, of course, passed to show that the aperture did actually communicate with the mouth-cavity. On opening the mouth the orifices in question were very plainly visible posteriorly. It will be noted that the gular sacs in this Frog, instead of being separate sacs as in *Rana*, are entirely confluent and form one median ventral sac, which is shown in the accompanying text-figure (text-fig. 128), as in *Rhinoderma darwini**. There is no trace of a division in the middle line of the body between the right and left sacs; they obviously form a continuous single narrow sac lying just behind the subhyoideus muscle opening at

Text-fig. 128.

Gular sac (S.) of *Megalophrys fœ.*

On each side the dark shaded orifice into the buccal cavity is seen.

either extremity into the mouth-cavity. The walls of the gular sac are rather extensive; but, as has been already mentioned, they are inserted in common on to the skin. This obviously would hinder any very great dilatation of the sacs. Furthermore, they could not extend in a dilated condition very far back along the body, for the septum between the lymph-sacs in the pectoral region would clearly prevent this. In *Rhinoderma*, on the other hand, "the main portion of the sac hangs free"†.

As to the musculature proper, the *rectus abdominis* shows no definite traces that were at all apparent to me of *inscriptiones tendineæ*, which seems to be rather an important difference from its nearest allies.

* Cf. Howes, "Notes on the Gular Brood-pouch of *Rhinoderma darwini*," P. Z. S. 1888, p. 231.

† Howes, *loc. cit.* p. 234.

The *pectoralis abdominalis* is not very extensive; it reaches back for about one-third of the distance between the end of the sternum and the symphysis pubis.

The musculature in the sternal region (see text-fig. 125, p. 394) does not entirely cover the bones and cartilages of the shoulder-girdle. The right epicoracoidal cartilage, which greatly overlaps ventrally the corresponding cartilage of the left side, is for the greater part bare of muscle. A large portion of the right coracoid bone and the triangular bony base of the sternum were also uncovered by muscle. In a second specimen, however, the pectoralis did extend over the triangular basal region of the sternum.

The *rectus abdominis* continues forward anteriorly after the origin of the pectoralis abdominalis and lies to the side of the sternum, separated from it, however, by a much narrower muscle which arises from the shaft of the sternum, and which I shall again refer to as a portion of the sternohyoideus. At the anterior end of the dagger-shaped sternum a portion of the rectus abdominis is inserted upon the lateral transverse extension of the "handle" of the "dagger." The rest passes onwards anteriorly and becomes a part of the sternohyoideus. I did not observe in the present species a tendinous connection of the rectus with the edge of the coracoid such as that figured in *Xenophrys monticola* *. Nor did I note any fibrous lateral expansion of the sternum, such as occurs in the species just mentioned, covering over the innermost section of the sternohyoideus muscle. If such a membrane were present it must have been excessively thin and delicate to have escaped observation.

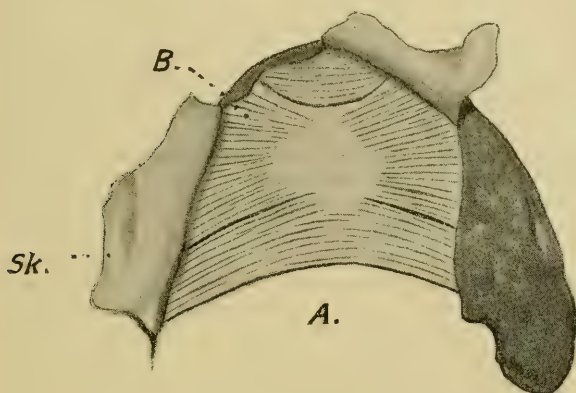
I have mentioned that in *Xenophrys* no superficial *sternoradialis* is visible; in the present species it is only superficial—and then covered by fascia—for a very short distance after its origin from the omosternum. It is thereafter covered by the pectoralis. The strong tendon was followed to its insertion, and there is thus no doubt about the presence of this important muscle in *Megalophrys feæ*. As the fascia in question is continuous with the pectoralis, the sternoradialis may be said to be completely covered by that muscle. The two (anterior and posterior) portions of the *pectoralis sternalis* are very distinct at their origin, on the right side at any rate, by reason of the exposed bony end of the coracoid which separates them. The origin of the pectoralis sternalis posterior extends about halfway down the bony shaft of the sternum, but appears to vary in individuals, in the extent of its attachment to the sternum, as the text-figure (text-fig. 125) referred to above shows.

The throat musculature of *Megalophrys feæ* is exhibited in the accompanying drawing (text-fig. 129). There are no prominent differences from the conditions of the corresponding muscles

* P. Z. S. 1907, p. 893, text-fig. 236, a.

observable in other Megalophryidæ. The *submentalis* is large and conspicuous anteriorly. In the middle of the area occupied by the two succeeding muscles is a tendinous sheet quite similar to that which I have figured in *Leptobrachium hasseltii**. This is concerned with the *subhyoideus* as well as with the *submaxillaris* muscle. The fibres of the latter radiate a good deal from the central tendon—that is to say, they do not cross the jaw space

Text-fig. 129.

Ventral musculature of the throat of *Megalophrys fœæ*.

Sk. Skin reflected. A. Subhyoideus. B. Submaxillaris.
Anteriorly to the latter is the submentalis.

evenly and in parallel lines from side to side, being only interrupted by the central tendon. The line of demarcation between the submaxillaris and subhyoideus is very distinct indeed. The submaxillaris, it should be remarked, completely covers over the submentalis, though it thins off in this anterior region of the throat.

§ Musculature of the Dorsal Surface.

The *depressor mandibulæ* seems to be very much as in *Rana* and is a stout muscle firmly attached in front to the skull, where it shows thicker in transverse section; it completely covers the scapula together with the *latissimus dorsi*, the two forming a continuous sheet of muscle. I have not mentioned the depressor mandibulæ in my two former papers upon the anatomy of the Pelobatidæ, and therefore take this opportunity of asserting its presence in the genus *Megalophrys*.

* "Contributions to the Knowledge of the . . . Pelobatidæ," P. Z. S. 1907, p. 884, text-fig. 232.

II. FURTHER NOTES UPON THE GENUS *BREVICEPS*.

Nearly three years ago I communicated to the Society some notes upon the anatomy of an African Frog belonging to the genus *Breviceps*, which I identified with the species *B. verrucosus* *. I am now of opinion that three Frogs upon which I reported on that occasion are not to be referred to this species, which I have lately examined. The specimens of *Breviceps verrucosus* and of *B. gibbosus*, which were exhibited at the Society's Gardens some years since, and of which several have been preserved in alcohol, are distinctly different from those to which I had devoted my attention in the paper already quoted. They are much more spherical in outline, agreeing with a published figure of *B. verrucosus* † and of *B. mossambicus* ‡. The examples formerly studied by myself were much longer in proportion and of a squarer outline. Furthermore, the examples of *B. verrucosus* and *B. gibbosus* in the possession of the Society are more tubercular upon the surface of the body. I am, however, quite unable to suggest the species to which the specimens dissected by myself in 1908 are to be referred. I cannot at any rate refer them to Mr. Boulenger's recently described *Breviceps macrops* §, for that species is abnormal (for *Breviceps*, though more normal when compared to other Frogs) by reason of the relatively large head and eyes. *Breviceps pentheri* of Werner || is quite too small a species to be confused with that to which I now refer, although the latter is considerably smaller than either *B. verrucosus* or *B. gibbosus*. The latter are hard to separate, as Mr. Boulenger has pointed out. A sixth species, *B. adspersus* ¶, appears to me to be too briefly described to permit of its identification with either the species with which I am now, or that with which I was, concerned.

The present contribution to our knowledge of this genus *Breviceps* is based upon the examination of four examples given to me by Mr. Purcell, who was so good as to have them collected in the Cape Colony. These seem to me to belong either to *B. gibbosus* or *B. verrucosus*, which I cannot differentiate to my own satisfaction and which are in any case very closely allied. Through the kindness of Mr. Purcell they were very well preserved for dissection purposes, and I am thus able to add something to the existing knowledge of *Breviceps*. I have already mentioned a few external differences between the present species and those which I dissected in 1907. I shall point out in the course of the following pages certain anatomical differences.

* Rapp, Arch. f. Nat. 1842, p. 291.

† Steindachner, Reise der Novara, Amphibien, Wien, 1867, pl. v. fig. 3.

‡ Peters, Reise nach Mossambique, Amphibien, Berlin, 1882, pl. xxv. fig. 2.

§ Ann. & Mag. Nat. Hist. xx. 1907, p. 46. Mr. Boulenger remarks that,

"Unlike *B. gibbosus*, *B. macrops* does not cover itself with a viscous secretion when alarmed." The species upon which I report in the present paper showed in one individual a thick mass of secretion on the body.

|| Zool. Anz. xxii. 1899, p. 116; the species is 15 mm. long.

¶ Peters, Reise nach Mossambique, Amphibien, Berlin, 1882.

between these members of the same genus. On the other hand, I am able to confirm certain structural features of the genus as formerly described by myself by finding an identical arrangement in these examples of *B. gibbosus*.

§ *Genito-urinary Organs.*

The *testes*, *fat-bodies*, and *kidneys* of *Breviceps gibbosus* do not altogether agree in their characters with my former description.

There is no doubt that the vasa efferentia of the testes are numerous, as is the general rule among the Anura. This fact I am clear about. So obvious are the several parallel sperm-ducts issuing from each testis, that I cannot understand how I can have been in error in describing only a single duct in the smaller species of *Breviceps*, if, that is to say, I was in error. Moreover, in *Breviceps gibbosus* the ureter arises from the lower corner of the kidney, and not from rather higher up as I have figured it in *Breviceps* sp.* The two kidneys are nowhere fused together in the middle line. It is worth recording that the fat-bodies have but few finger-like processes; I found two and three in one specimen and three and four in another. But these structures are known to vary.

§ *Respiratory Organs.*

The *lungs* of *Breviceps gibbosus* present several features of interest. Each lung itself (in the contracted condition in which it appears in the alcohol preserved specimens) is broader at the base and narrows towards the free abdominal extremity. It is important to notice that both extremities of the lung are free and that the bronchus enters that organ at about the second third of its entire length. The lung is thus not merely a sac dependent from a rudimentary trachea. Furthermore, two bronchi are very plainly differentiated. Each is, in fact, about half as long as the lung (contracted, of course) into which it opens. It is proportionately wide and enters the lung at right angles to the long axis of the latter viscus. Its walls are membranous and translucent and I could detect no cartilages. The pulmonary ligament fixing the lung to the dorsal middle line extends along the whole of the bronchus and just on to the lung.

If I have not in any way misread the conditions which obtain in the species of *Breviceps* † dissected three years since, that species shows considerable differences from *Breviceps gibbosus* in the relations of the *œsophago-pulmonary* muscle ("diaphragm"). There are, however, also points of agreement between the two sets of individuals. For instance, the muscle arises in both in the same way from a vertebral transverse process nearly in common with the transverso-scapularis. Furthermore, in both cases the

* P. Z. S. 1908, p. 38, text-fig. 13.

† *Loc. cit.* p. 27, and text-fig. 7, p. 28.

œsophago-pulmonary muscle is closely associated in function with the hindermost of the petrohyoid muscles.

Here, however, the principal resemblances end and there remain certain important differences.

The most important of these points of difference is that the muscle which we are discussing has no relations whatever, except those of contiguity, to the respiratory organs. I believe that I can assert this fact with confidence; but I have no reason to doubt the essential accuracy of my description of the other species of *Breviceps*. The difference in this particular may be due to the extraordinary development of the bronchi in *Breviceps gibbosus*. In this species, the insertions of the œsophageal muscle and of the hindermost petrohyoideus are as follows:—Two muscles are seen to be inserted on to the ventral surface of the œsophagus, fanning out somewhat at their insertion, which falls short of the middle ventral line. It is perfectly clear, when these muscles are followed back, that they have no attachment (distal) other than to the surface of the œsophagus. The œsophageal muscle is the larger of the two, and it partly forms an arch over the œsophagus which is not attached to it; some of its fibres, that is to say, run from one vertebral transverse process to the corresponding one upon the opposite side of the body. The rest are inserted upon the œsophagus; but they pass underneath the fibres of the petrohyoideus and are inserted laterally to them. The insertion of the petrohyoideus upon the œsophagus appears to me to be quite as extensive and important as is that of the œsophageal muscle itself.

§ *Alimentary Tract.*

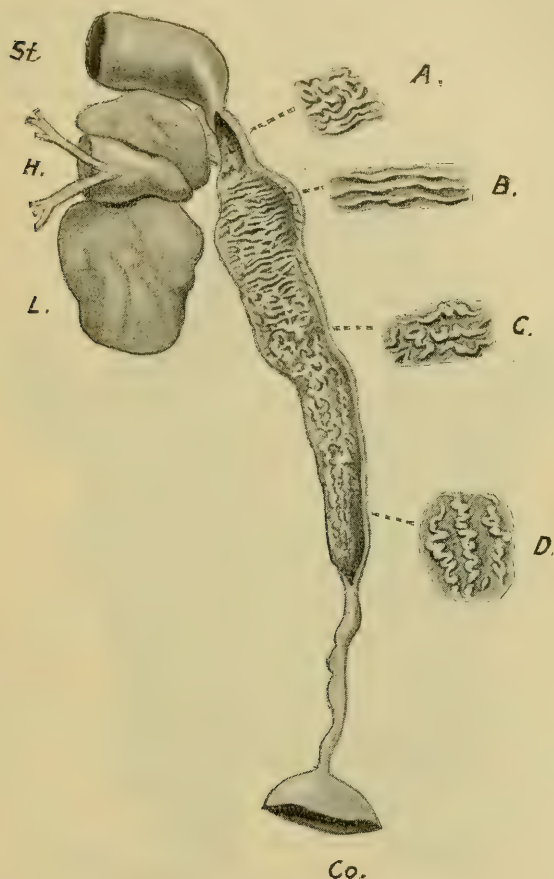
I have had represented in the accompanying text-figure (text-fig. 130) the *intestinal tract* of an example of *Breviceps gibbosus*, which has been opened up for the greater part of its length. The general aspect of the intestine of this species is very like that of the species which I formerly described*, and it can be divided into precisely the same regions. In the present species the duodenum measured 7 mm. in length; the ensuing wide region of the intestine was double this length, viz. 14 mm.; the long narrow terminal region, which opens into the colon, was again double the length of the preceding region and measured 29 mm. The short duodenum shows externally a division into small and approximately equal rounded areas. This appearance was also seen internally where the folds of mucous membrane constitute a network.

In the wide region of this gut the folds are circular and precisely as I have described them in the other species. In the terminal region of the small intestine the folds are entirely longitudinal, and there is a transitional area which is also indicated in the accompanying text-figure.

* P. Z. S. 1908, p. 32, text-fig. 10.

The stomach has much the same character as in the other species; but the contents were quite different. In the stomach described here were the remains of a largish beetle and an entire and quite large beetle larva and some other insects.

Text-fig. 130.



Alimentary tract of *Breviceps gibbosus* with the greater part of the small intestine laid open.

A-D. Portions of the different regions of the intestine more highly magnified.

Co. Colon, cut short. H. Heart. L. Liver. St. Stomach.

The text-figure to which I have referred in describing the intestinal canal (text-fig. 130) also shows the liver, which is a little different from that of the other species of *Breviceps* whose anatomy has been described by myself. The heart is not at all

covered by the liver in the species *Breviceps gibbosus*. There is, however, as I have illustrated by figures*, some individual difference in the liver in this genus.

§ On certain Characters of the Skeleton.

I did not notice particularly the sternum of the other species of *Breviceps*; in *B. gibbosus* the form is not at all as it is figured by Parker in his 'Monograph of the Shoulder-Girdle'†, nor is it like the woodcut given by Boulenger in the 'Catalogue'‡. The cartilaginous plate is much more important than would be gathered from those figures, and expands laterally into a curved and thinnish process. It is, in fact, very like the sternum of *Discoglossus pictus* as figured by Boulenger§.

Two other features in the skeleton of this frog were commented upon by myself in the earlier account of the anatomy of this genus. I naturally endeavoured to ascertain if those peculiarities were to be found in *Breviceps gibbosus*, and I find that the species which forms the subject of the present notes has the plate of cartilage lying upon the expanded sacral transverse process, and that the anterior cornua of the hyoid are perforated in exactly the same fashion||. I need not give a more prolonged description of these peculiarities, which appear to be identical in the two species.

§ On certain Muscles.

Many of the muscular peculiarities of the species described in my earlier paper occur also in the species now under consideration. It is, perhaps, important to enumerate such of these as I have verified, in order to confirm them—for they are unusual—and also in order to point out that they are apparently characteristic of this genus or at least of more than one species. I shall not, however, give a long description of them. In the first place, the *latissimus dorsi* (see text-fig. 131), not a very large muscle, is completely covered over by the double sheet of the *obliquus*. There is also no trace of the posterior part of the *depressor mandibulae*. I did not note in my paper whether the cephalic portion of this muscle was present. I find that it is present in *B. gibbosus*. In the present specimens also the suprascapula is largely exposed anteriorly when the skin is removed, on account of the absence of the posterior part of the muscle just referred to. It is covered, however, by a tough fascia. Furthermore, the dorsal muscle of the suprascapula, the *infraspinatus*, is quite visible without removing any other of the dorsal muscles.

The *rectus abdominis* is nearly as in *Breviceps* sp., where I have figured it. In *B. gibbosus* I could find one superficial

* P. Z. S. 1908, p. 30, text-fig. 8.

† Pl. vii. fig. 9.

‡ 'Catalogue of Batrachia Salientia,' 1882, p. 176.

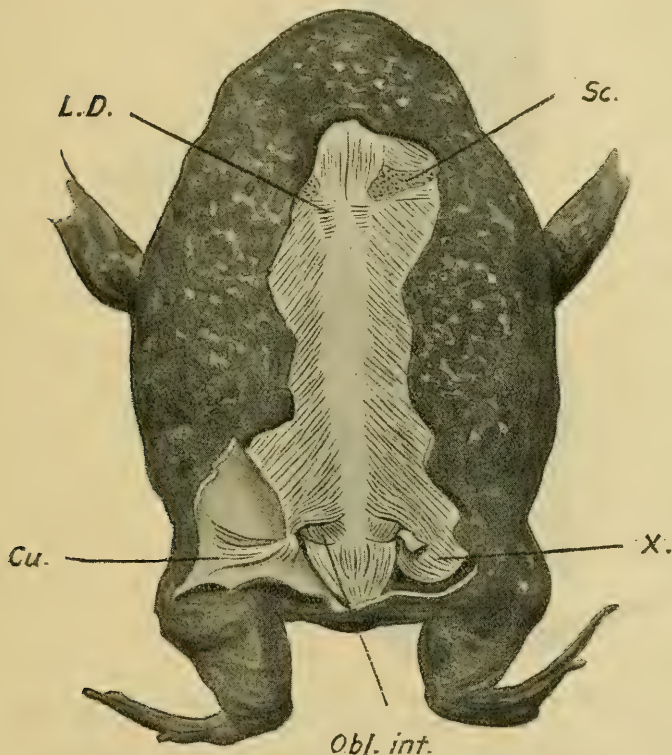
§ 'Tailless Batrachia of Europe,' Ray Soc. Publ. 1897, vol. i. p. 40.

|| Cf. P. Z. S. 1908, p. 12, text-fig. 2.

inscriptio tendinea*, behind the origin of the *pectoralis abdominalis*. This muscle arose a little in front of the first and only visible inscriptio tendinea.

The other abdominal muscles, q. s. *omo-abdominal*, *hyo-abdominal*, and *obliquus internus*, are quite as I have described them in my former paper, except that the *hyo-abdominal* seems to be rather larger. This muscle passes under the lateral process of the sternum, i. e. dorsally to it, and would thus appear to belong to the *obliquus internus* sheet, and not, as I formerly suggested, to the *obliquus externus*.

Text-fig. 131.



Breviceps gibbosus, from the dorsal surface, partly dissected.

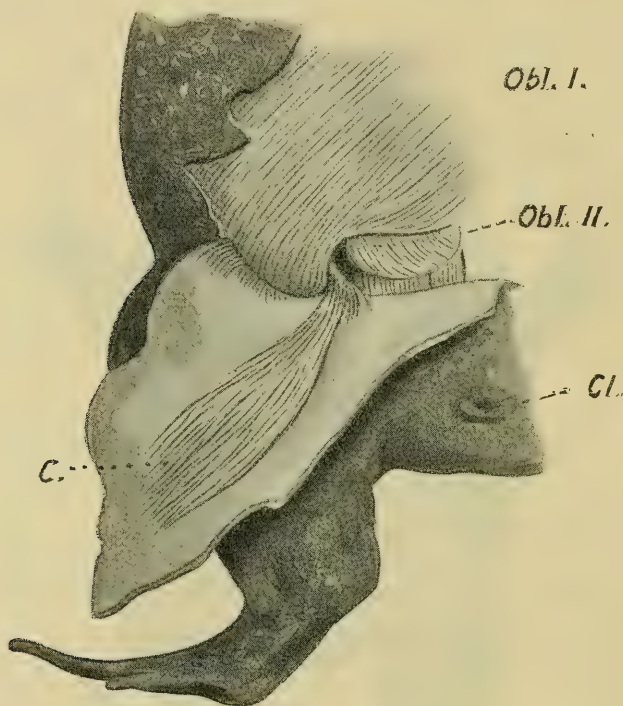
Cu. Cutaneous muscle. *L.D.* Latissimus dorsi. *Obl.int.* Obliquus internus.
Sc. Scapula. *x.* Slight bulge of dorsal musculature referred to in text.

The *obliquus externus* is rather different from that of the species of my former description. The fascia dorsalis is quite obvious, and the origin of the muscle is thus some way removed from the

* *Loc. cit.* p. 23, text-fig. 5

middle line of the back (see text-fig. 131). Its fibres run obliquely backwards and are massed into coarse strands at the origin of the muscle. The origin of this muscle extends further back than was formerly described, and covers the obliquus internus until very near to the end of the line of origin of the latter. The obliquus internus only becomes superficial for a very short distance posteriorly. These differences may be seen on a comparison of

Text-fig. 132.



An enlarged view of a portion of text-fig. 131, to show absence of diverticulum of body-cavity overlying thigh.

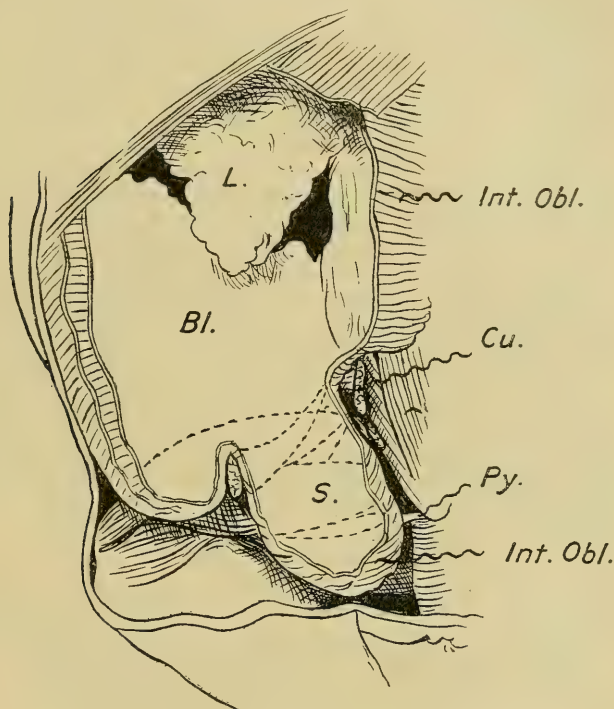
C. Cutaneous muscle. *Cl.* Cloacal aperture. *Obl.i.* Obliquus externus.
Obl.ii. Obliquus internus.

text-fig. 131, p. 409, of the present communication, with text-fig. 4, p. 20, of my paper on the other *Breviceps*. I am able to confirm the statements about the latter species, so far as the points at issue are concerned, by the examination of a specimen given by me to the Royal College of Surgeons, and dissected by Mr. Burne.

The aforesaid figure (text-fig. 131), which is to be compared

with text-fig. 4 of my previous paper upon this genus, not only shows the differences in the oblique muscles already referred to, but indicates the nearly total absence of anything comparable to those structures which I identified in my former paper with very much enlarged lymph hearts. There is, indeed, a slight bulge of the abdominal wall posteriorly, but it does not extend over the dorsal surface of the thigh; nor is this bulging at all detached from the

Text-fig. 133.



Copy of a drawing by Mr. R. H. Burne, illustrative of certain parts in the anatomy of *Breviceps* sp. referred to in the text.

Bl. Body-cavity. *Cu.* Cutaneous muscle. *Int.Obl.* Obliquus internus. *L.* Lung. *Py.* Pyramidalis. *S.* Diverticulum of body-cavity overlying thigh.

The muscles of the thigh are indicated by dotted lines.

abdominal wall. It will be easily seen from an inspection of text-figure 132 that an extension of the body-cavity on to the dorsal surface of the thigh is impossible in the present species. For, as will be seen in the last figure referred to, a ridge of cutaneous muscle ties the commencement of the thigh to the skin and thus

effectually prevents any hernia-like outpushing of the abdominal cavity backwards. There is thus an important difference between the species with which I am now concerned and that which formed the subject of my earlier paper.

With reference to the latter species, I am able, through the kindness of Mr. R. H. Burne, to submit a drawing of a dissection made by that anatomist on a specimen of the toad which I presented to the Royal College of Surgeons. Having also seen the actual dissection, I am obliged to admit that Mr. Burne has proved that my former account of this region of the body was not correct in every detail. Mr. Burne has ascertained and has demonstrated to me that the structure which I termed a "lymph heart" is a diverticulum of the body-cavity, lying, however, on the leg, as is clearly shown in the accompanying drawing (text-fig. 133, p. 411). This connection was so wide that the bladder had floated into the diverticulum.

I feel convinced, however, that the communication was not so wide in the larger female example dissected and figured by myself. For the diverticulum was easily detached from the surrounding structures, a fact which argues some independence, as it would seem at least to show that the orifice into the general thoraco-abdominal cavity can contract. Furthermore, the arrangement of the oblique muscles in the region is rather different from what may be seen anteriorly. Thus we have, certainly in this species, a specialized portion of the thoraco-abdominal cavity (which is recognisable, but much less prominent, in *Breviceps gibbosus*) extending over the dorsal surface of the thigh. It is not, however, I now admit, possible, in the present state of our knowledge, to speak of this as a "lymph heart." I propose, however, to defer any further consideration of this subject until more facts have been accumulated.

21. On the Spermatophores in Earthworms of the Genus *Pheretima* (= *Perichæta*). By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received December 28, 1910: Read March 7, 1911.]

(Text-figures 134-136.)

I believe that there is no account of the spermatophores in this genus of Earthworms; and at least there has not been, to my knowledge, anything more than the briefest reference to their occurrence. It might be expected from analogy that this genus, like so many others, possessed this means of impregnation; but I can recall no figures of such structures. Even supposing that I have involuntarily ignored such an account, it is worth while to add something more to the subject, which cannot be well known.

I have lately examined, and shall shortly report upon, a collection of terrestrial Oligochaeta from the Philippine Islands, the opportunity of examining which I owe to the kindness of the Director of the Scientific Bureau of the Philippines. I found these structures in two species contained in that collection, one of which I propose to describe as a new species, and the other of which is, as I believe, identical with *Pheretima montana*.

In the first-named species, which is very close to that which I call, in my revision of the genus*, *P. cingulata*, there are four pairs of spermathecae. In all of these, in individuals which I examined for the present purpose, I found spermatophores, but only one or two in each pouch. They are oval bodies with a long spout-like projection, like a pear with a long stalk. It appeared to me, on examining these mounted in glycerine entire, that the prolongation did not open on to the exterior, and that the sperm had therefore no obvious means of escaping from the case which contains it. If my observations are correct, they do not, as will appear shortly, imply anything anomalous; for the sperm has another way of escape. In the species which I identify with *P. montana* there is only a single pair of spermathecae. But in each spermatheca was a much larger number of spermatophores. There is an obvious relation here between the total number of spermatophores in the two species. In the former species, moreover, the spermatophores had a longer spout-like projection than in *P. montana*.

The accompanying figure (text-fig. 134, p. 414) illustrates a spermatheca of *P. montana*, cut open and still containing two of the spermatophores, while two others lie in the vicinity. There are also three other spermatophores in this particular spermatheca, making a total of seven. In other cases I have noticed the same, or nearly the same, number of these bodies. The figure referred to shows the shape of the spermatophores quite well. They vary slightly in size, being not more than a millimetre in length, and are spherical to oval with a narrow duct-like prolongation. The shape, in fact, is quite consistent with the view that they are spermatophores. They do not, however, agree absolutely in their form with those of any Annelid which has been up to the present described. In view of the considerable differences which spermatophores show in different genera and families of Oligochaeta, this would hardly be expected. On the whole it appears to me that they most resemble those of *Pareudrilus*, described by myself† and Cognetti de Martiis‡.

The spermatophores when viewed with the naked eye or with a hand-lens have a glistening white appearance, which is explained by their minute structure, as will be apparent later. I did not

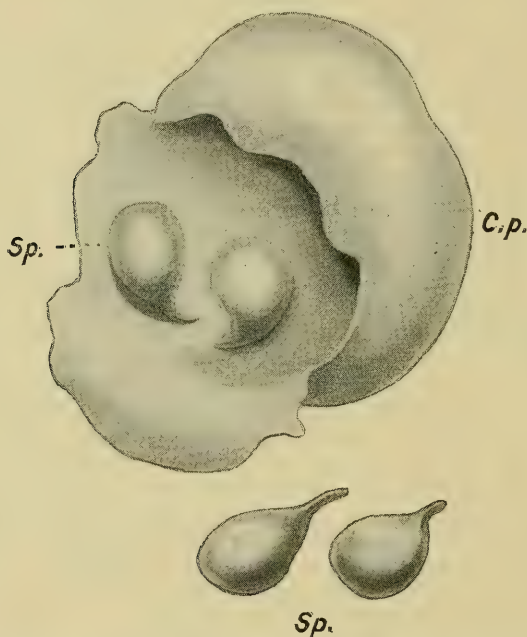
* "A Revision of the Genus *Amyntas*," P. Z. S. 1900, p. 609.

† "On a new Genus and two new Species of Earthworms, &c.," P. Z. S. 1903, p. 210.

‡ "Contributo alla Conoscenza della fecondazione negli Oligocheti," Atti Acc. Sci. Torino, xlv. 1910.

observe any case where the spermatophores were sticking on to the surface of the body of the worm, as they do in the Lumbricidæ, in *Alma*, in *Bothrioneuron*, and among the Leeches. The fact that so many were crowded together in one spermatheca in the species figured here seems to be some evidence in favour of regarding the spermathecae as *not* being their place of origin. There are also some other facts which favour the same negative supposition. The size of these bodies is small; and it seems difficult to imagine that they could be moulded in the spermathecae, which are comparatively so large. It might be held, indeed, that the narrow spout in which the spermatophore ends was moulded by the compressed duct of the spermatheca; but this leaves the larger body of the spermatophore unaccounted for.

Text-fig. 134.



Spermatheca (*C.p.*) of *Pheretima montana* containing spermatophores (*Sp.*).

I believe that I showed some reason for regarding the spermatophores of *Benhamia austeni** as entirely formed in the spermatheca and its appendage. But it is equally or perhaps more certain that in other species of Oligochæta the spermatophores are moulded in the glands appended to the male ejaculatory

* "On the Spermatophores in the Genus *Benhamia*," P. Z. S. 1901, p. 704

apparatus. Although one might suppose that in two genera, which are probably to be regarded as nearly akin, the formation of the spermatophores would be identical, there is in the *Pheretima* now under consideration some positive evidence to show that the spermatophores are formed in the terminal sac of the male ejaculatory apparatus. In this species, as in other *Pheretimas*, the spermiducal gland ends in a narrow muscular duct which appears to open into a wide terminal bursa copulatrix. The latter, of course, opens on to the eighteenth segment by a conspicuous orifice. When sections are made through this terminal apparatus it is seen that the cavity of the bursa copulatrix is by no means so large as the peripheral measurements of the sac would lead one to imagine; but that the greater part of its cavity is occupied by a large penis, which can doubtless be protruded. This penis, which is of a conical form, is surrounded by the cavity of the bursa, which, however, lies chiefly to one side, and there is in that region, therefore, a space of moderate dimensions which is not far from the size of one of the spermatophores. Furthermore, the cells which line this cavity, except near to its external orifice, are tall, and the glandular-looking cells stain badly, and thus appear to be full of some hardly stainable secretion. The muscular duct leading from the spermiducal gland is joined at about the end of the first fourth of the penis by the sperm-duct (here single and apparently not ciliated), and the conjoined duct opens not on to the end of the penis, but rather to the side, *i. e.* inside the cavity of the bursa copulatrix, so that it might inject the sperm into the cavity of the bursa. This sperm might then be surrounded by an excretion of the glandular cells of the bursa, and thus emerge a complete and fully charged spermatophore. This is admittedly a mere suggestion, and is far from being a conclusive statement. I have, however, no further evidence.

Reverting to the spermatophores themselves, they show, when examined entire with a low power of the microscope, an opaque appearance, less marked naturally at the free tail-like termination. The opacity is doubtless responsible for the white appearance of the body, and is very different from what one would expect in a spermatophore. Presumably with chitinous walls it would be supposed that it would present a transparent, or at least translucent, appearance when examined by transmitted light. This is, however, not the case at all. Moreover the walls of the spermatophore have not a regular outline, but are roughened, as if many minute particles were adherent to the outside. This is not in any way different when the bodies are examined in glycerine. The roughened and opaque exterior prevents a clear view of the contained sperm, and, indeed, it would be impossible to state from such an examination only that there was any sperm within. Viewed in its entirety in glycerine not much more is to be learnt about the spermatophore than is taught by an examination of it as an opaque object with a lens. I have,

however, studied these bodies by the section method, which has allowed me to describe a good many facts concerning their structure, though something remains to be discovered, as will in due course be pointed out. The wall of the spermatophore is the first part of the structure which calls for attention. This is of some thickness, as is shown in the accompanying figure (text-fig. 135); but it is not thicker than that of other spermatophores. Its structure, however, is remarkable, and in some respects unique, at any rate at first sight. The minute structure of the

Text-fig. 135.

Longitudinal section through spermatophore of *Pheretima montana*.

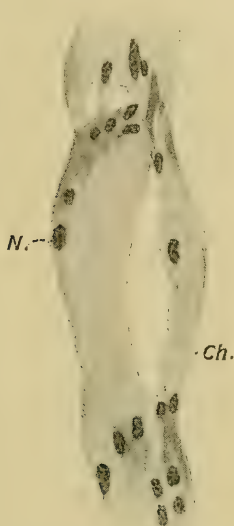
S. Spermatozoa massed at apical end of case.

M. Mucous and granular substance filling up blind end of case.

wall is illustrated in the accompanying figure (text-fig. 136). At first sight, the wall of the spermatophore suggests a living tissue allied to connective tissue or even muscle. We recognise many nuclei, which occur outside, inside, or within the wall itself. These nuclei are not in any way degenerate structures, and their varying position shows that they are not merely fragments adherent to a sticky structureless wall. For they lie within as well as on both sides of it. In addition to these cells there is a structureless substance which in parts has a fibrillar character. The likeness to muscle is thereby much enhanced. It occurred to me at first that the wall might be actually an adventitious sheath formed by the tissues of the worm's body, and comparable to the sheaths found round foreign bodies when introduced from the outside, or

to the "paruterine organs" of Tapeworms. It may be that this interpretation is correct. But I do not myself hold this view for other reasons, which will be explained. That portion of the wall of the spermatophore which is lettered "*Ch*" in text-fig. 136 seems to me to give the clue to the real nature of the wall. It will be noted that we have a thickish and structureless layer which is surrounded on both sides by cells. The clear layer is not much stained by the carmine, and is quite reasonably to be regarded as the actual unaltered structureless wall of the

Text-fig. 136.



Transverse section through wall of spermatophore of *Pheretima montana* much more highly magnified than in text-fig. 135.

Ch. Chitinous layer. *N.* Nuclei of phagocytes (?).

spermatophore, probably of chitinous nature. Elsewhere the same structureless substance is found which shows evidence of being hollowed out. These facts thus briefly stated lead me to the inference that we have here a spermatophore in which the original chitinous wall is being gradually eaten away by leucocytes. I do not see any other view which fits in so well with both fact and probability.

Indeed, the only other interpretation of the histological facts, which is not very much borne out by the relations of the cells to the membrane, is to suppose that the case of the spermatophore is built round a mass of sperm lying in the spermatheca, a suggestion which, apart from the actual facts, is not at all probable. I feel

fairly confident that the phagocyte theory is the correct one to explain the anomalous appearances seen in the case of the spermatophores of this *Pheretima*. As to the origin of the phagocytes, I have no facts to offer. This is, however, not a weak point in the argument that they are phagocytes. The cells are as cells small; the nucleus is very large compared with its surrounding protoplasm. But the immense numbers of the cells makes up for the lack of non-nuclear protoplasm, and the large nuclei are an indication of their activity. The presence of these cells leads to the rapid and dark staining of the spermatophores, which is very noticeable, and not what would be expected in such a structure, on the view that its walls were entirely chitinous. I obtained the clue to the nature of the processes going on in the spermatophores of this Oligochaete when within the spermatheca by a consideration of an important recently published paper by Dr. Cognetti de Martiis. The author promises a further contribution on the rôle played by phagocytes in the destruction of superfluous spermatozoa; but this memoir I have not yet seen. In the memoir which I have read and the title of which is quoted below*, Dr. de Martiis observed that the spermatozoa leave the large spermatophore, and suggests that the fibrils of the wall of the latter are caused to diverge, and thus leave room for the exit of the spermatozoa, by the action of certain cells against which the end of the spermatophore is pressed, and which form part of the lining epithelium of the spermathecal sac. A chemotactic influence leads on the spermatozoa from cell to cell until they reach the egg-sacs. He thinks that the weak and dying spermatozoa are devoured by phagocytes, and has figured spermatozoa in the interior of phagocytes. This, however, is a quite different series of events from what takes place, as I believe, in *Pheretima*. Here, I repeat, there is some evidence for regarding the phagocytosis of the walls of the spermatophore as a means of liberating the enclosed sperm.

The contents of the spermatophore now demand attention. The cavity of the spermatophore is not entirely filled with spermatozoa. As will be seen in text-fig. 135, the mass of spermatozoa is limited to the lower half of the spermatophore. It occupies hardly half of the whole space available. The mass of spermatozoa is strictly delimited above, and the line of demarcation is a regularly curved line. I think it possible to detect a delicate membrane surrounding the mass of spermatozoa and to be distinguished from the substance to be shortly described which fills up the rest of the cavity of the spermatophore. The inclusion of the spermatozoa in a case independent of the case of the spermatophore itself, and lying within it, is a fact of likeness to the spermatophores of *Benhamia*†, where something of the same kind occurs. It is possible also that the delicate case of the spermatozoa is fabricated in the appendix of the spermatheca.

* "Contributo alla Conoscenza della fecondazione negli Oligocheti," Atti Acc. Sci. Torino, xlv. 1910.

† P. Z. S. 1901.

But if this be so, the whole question of the place of formation of the spermatophore will have to be reconsidered. I have, indeed, no positive facts concerning the reasons for the rounded outline of the mass of spermatozoa.

The arrangement of the spermatozoa requires some description. They are not massed higgledy-piggledy with the heads and the tails pointing in any direction; the arrangement is a perfectly regular one. The heads of the spermatozoa are all on that side of the sperm-mass which is nearest to the "stalk" of the spermatophore. The upper part of the sperm-ball is composed entirely of the tails, which are not disposed in straight lines, but are waved and curved in every direction. The heads radiate outwards in a quadrant or a little more perhaps. The actual heads are in close contact with the walls of the spermatophore, and some of them descend for a space into the narrow duct of that organ. This rather looks as if they were so disposed for easy egress at the time when the sperm has to leave the spermatophore, which suggests that the phagocytosis of the case is not a necessity for fertilisation. It may be also that the spermatozoa escape, as Cognetti de Martiis thought of the spermatozoa of *Pareudrilus pallidus*, through the actual membrane of the spermatophore case, the action of the phagocytes facilitating their egress by widening the strands of the wall.

In any case the fan-like radiation of the heads of the spermatozoa agrees with the idea that those which are more laterally placed, and do not face the external spout-like orifice of the case, may make their way out through the actual walls.

In addition to the spermatozoa the spermatophore contains a granular mass which fills up the available space above the delicate case containing the spermatozoa. This granular mass has the appearance of broken-down cells. A comparison at once suggested itself with the granular substance described by Whitman in the spermatophores of *Clepsine**. In the Leech, however, the granular contents of the spermatophore lie near to the external orifice of the spermatophore, and seem to clear the way from in front of the subsequently issuing spermatozoa, or to perform other functions which are discussed by Whitman. Like Whitman, I was first disposed to regard the granular contents of the spermatophore of *Pheretima* as being of a cellular nature. I believe, however, that the substance is not composed of cells, though probably of broken-down cells.

The position of this granular mass at the apex of the spermatophore suggests that it may be of mechanical assistance† in expelling the sperm, supposing that the latter is usually expelled through the mouth of the spermatophore, and not liberated by

* Journ. Morph. vol. iv. p. 361.

† See also Brumpt, "Reproduction des Hirudinéés," Mém. Soc. Zool. France, 1900, p. 286. But Kovalevsky (Comptes Rendus, vol. cxxix. 1899, p. 261) did find cells which he regarded as phagocytes to eat the spermatozoa.

the eating away of the case. Furthermore, if the case be water-tight, the presence of this possibly largely fluid mass may be advantageous to the spermatozoa, especially if their sojourn in the spermatophore be long. Its function may be to keep the sperm moist and active. This is, however, mere supposition, and so little is known about the processes of fertilisation in the Oligochaeta that no safe guess can be hazarded. But it seems clear from the large mass of granular substance that it plays some important function in fertilisation.

22. A Rare Beaked Whale.

By R. LYDEKKER.

[Received December 19, 1910: Read March 7, 1911.]

(Text-figures 137-139.)

Some months ago—I believe early in the present year—a Beaked Whale was stranded on the beach near Port Elizabeth, which fortunately came under the notice of Mr. F. W. FitzSimons, the Director of the Museum in that city. Photographs were taken of the specimen as it lay, and the skeleton was subsequently cleaned and placed on exhibition in the Museum. As it lay, the specimen measured $15\frac{1}{2}$ feet in length, from the tip of the muzzle to the end

Text-fig. 137.



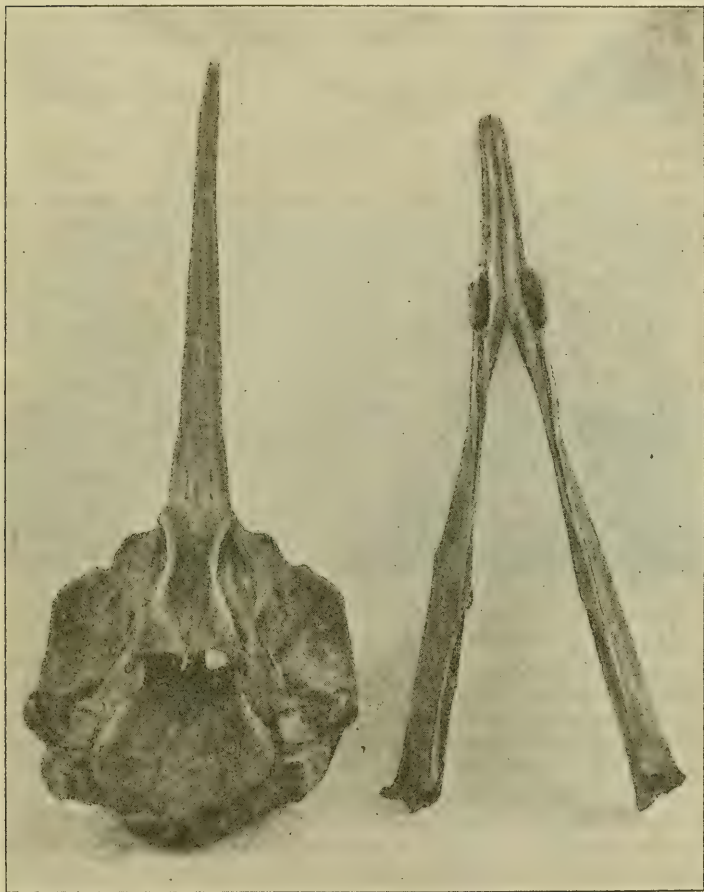
Mesoplodon (Dioplodon) grayi as it lay on the beach.

The back-fin had been hacked by natives.

of the flukes. In colour it was jet-black all over; and the flukes was remarkable on account of the posterior border being convex, instead of deeply emarginate, as in ordinary cetaceans. The skull, of which Mr. FitzSimons forwarded the two photographs herewith reproduced, indicates that the specimen is referable to the genus *Mesoplodon* (as commonly understood); this being manifest from

the presence of the single pair of large teeth just behind the hind end of the symphysis of the lower jaw. These teeth are, however, quite different in shape from those of Sowerby's Beaked Whale (*M. bidens*)—a species unknown in the Southern Seas; and the whole jaw is likewise different, as Mr. FitzSimons has pointed out, from

Text-fig. 138.

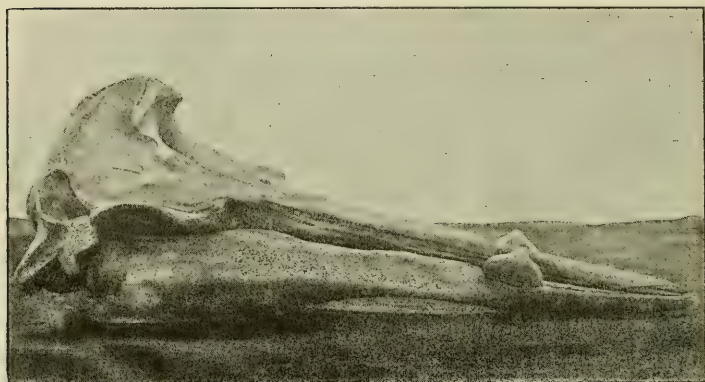


Palatal aspects of cranium and lower jaw of *Mesoplodon* (*Dioplodon*) *grayi*.

that of the South African Blainville's Beaked Whale (*M. densirostris*), in which the form of the teeth is also distinct. On the other hand, in the great size of their basal portion and the upright position of the terminal cap, the teeth agree exactly with those of

the imperfect skull from New Zealand described and figured by Sir William Flower, in the 'Transactions of the Zoological Society,' vol. x, p. 421, pl. lxxii. fig. 3, 1878, as a new species, under the name of *Mesoplodon haasti*. That so-called species has, however, been identified by Dr. H. O. Forbes, in the Society's 'Proceedings' for 1893, p. 218, with the New Zealand species previously named *M. grayi*, of which it represents a very old individual, the functionless small upper teeth found in younger specimens having been lost. Assuming this identification to be correct, which I think is probably the case, the Port Elizabeth whale would appear to be also a fully adult specimen of *Mesoplodon grayi*, and therefore of great interest as showing the extension of the range of the species to South Africa.

Text-fig. 139.



Lateral view of skull of *Mesoplodon* (*Dioplodon*) *grayi*.

But this is not all, for while, as already mentioned, the Port Elizabeth Beaked Whale has the hind margin of the tail-fin convex, in Sowerby's Beaked Whale it is deeply emarginate, as is well shown in De Blainville's figure reproduced on page 255 of the 'Study of Mammals.' A feature similar to that found in the tail of the Port Elizabeth specimen is stated to occur in a Beaked Whale from Annisquam, Massachusetts, which Dr. F. W. True (Bull. U.S. National Museum, no. 73, p. 10, 1910) refers to *M. densirostris*, a near relative of *M. grayi* (with which *M. australis* is identical); and it therefore seems that these two species form, at least, a distinct sub-generic group, for which the name *Dioplodon* is available.

I may add that I am indebted to my friend Mr. G. A. Boulenger for handing me the original communication from Mr. FitzSimons.

23. Age-Phases of the Rorqual.

By R. LYDEKKER.

[Received December 20, 1910 : Read March 7, 1911.]

Some months ago I received a communication to the effect that one of the captains at the Norwegian whaling-stations on the Mayo coast was surprised to find that the true Rorquals of the species commonly known to English naturalists as *Balenoptera musculus* found in the Irish seas differed from those he was accustomed to take in Norwegian waters, not only in colour, but likewise in their food. This species is stated in text-books to feed largely on fish, especially herrings and pilchards; and those taken in Norwegian waters by the captain above mentioned appear to have been exclusively fish-eaters. On the other hand, those taken on the Mayo coast in summer were feeding exclusively on pelagic crustaceans. As to the nature of the colour-differences between Norwegian and Irish examples, I was unable, in spite of special inquiries, to obtain definite information. I find, however, that Professor R. Collett, in a paper on Rudolphi's Rorqual, published in the Society's 'Proceedings' for 1886, states (p. 265) that in the True or Common Rorqual the whole of the under surface of the flukes is white; this statement being doubtless based on Norwegian specimens. On the other hand, in the life-size model in the Natural History branch of the British Museum of a specimen taken in the Moray Firth in the spring of 1880 the under side of the flukes is coloured black. This colouring is doubtless based on notes or a sketch taken when the specimen was in the flesh; and, for what this is worth, its correctness is confirmed by the fact that in the flukes itself, which is preserved in the Museum, no difference in the colour of the upper and lower surfaces is noticeable. In this connection it is important to mention that specimens of this Rorqual have been taken off Cornwall—in one instance in September—while feeding on herrings and pilchards*.

This was the extent of my information on the subject till a few days ago, when Dr. S. F. Harmer put into my hands some notes on Norwegian Rorquals he had recently received from a correspondent. From these notes, which are based on information furnished by an experienced Norwegian whale-gunner, it appears that the whalers of Finmarken recognise three varieties, or phases, of True Rorqual—namely, a darker, a lighter, and a yellowish. The dark phase is stated to be always met with in company with shoals of herrings, upon which it doubtless feeds. These Rorquals usually arrive off the Faroes in the middle of June, coming from the south-west and proceeding in a north-easterly direction; the immigration lasting till about the middle of July. Early in August the whales commence their return journey southwards, when they keep principally to the south side of the islands. By the end of the same month nearly all have

* See Gray, Cat. Seals and Whales Brit. Mus. p. 149 (1866).

left the Faroes, the few that remain being restless and evidently on the move.

The most important item in this statement is, however, that these Rorquals arrive off Finmarken in two divisions, the first of which is composed of members of the dark phase—which I presume to be represented by the above-mentioned dark-tailed specimen. These dark whales arrive early in March and advance in an easterly direction, but do not, as a rule, go beyond the Varanger Fiord, whence they return in the middle of April along the coast; the migration being completed by the end of the latter month.

The second division consists chiefly of the two lighter-coloured phases, which I take to correspond with the light-tailed form described by Prof. Collett. Nothing is said as to the nature of their food; but it seems highly probable that it is this light-coloured phase which is taken off Mayo feeding on shrimps, &c. The members of this second division reach the Faroes in the first half of June, and are then met with about fifteen miles off Sörö, where they stay till about the beginning of July, when they move eastwards as far as Baadsfiord, whence they finally disappear in a north-easterly direction.

Schools composed chiefly of the light-coloured and yellow phases reach Spitzbergen in the middle of June and move on towards the north-east; returning along the coasts of Spitzbergen from about the end of July, and disappearing by the middle of August.

The existence of one dark and two light phases of this Rorqual being thus clearly established, and it being also known that the dark phase is the one associated with herring-shoals, it remains to account for these differences. One explanation would be that we have to do with distinct races; but although such an explanation might be entertained if we had to do with two phases only, it is difficult to accept when there are three. The alternative is to regard the three colour-phases as representing differences in age. Cetaceans of many kinds are known to show considerable variation in colour according to age; a notable instance being afforded by coloured casts of two Norwegian examples of Sowerby's Beaked Whale (*Mesoplodon bidens*) exhibited in the whale-room at the British Museum. In the smaller of these the belly is pinkish yellow, whereas in the larger example it is as black as the back. So different, indeed, are the two specimens, that I at one time considered they might be specifically distinct. I believe, however, that Norwegian naturalists regard the black-bellied phase as the fully adult condition of the white-bellied form; and if this be correct, there is every reason for regarding the colour-phases of the Rorqual as being likewise dependant upon age. Assuming the colour-changes of the Beaked Whale to be paralleled in the Rorqual, the dark phase of the latter should be the oldest; and that this is the case is indicated by the skeleton of the aforesaid specimen in the British Museum, which is that of a very old individual, as is shown by the complete welding of the epiphyses to the centra of the vertebræ. It may be also confirmed by the black-tailed Rorquals being those which feed on herrings and pilchards.

24. On Longevity and Relative Viability in Mammals and Birds; with a Note on the Theory of Longevity. By P. CHALMERS MITCHELL, M.A., D.Sc., LL.D., F.R.S., Secretary to the Zoological Society of London.

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INTRODUCTION.

Animals are mortal, and we know that death comes to them after durations of life that differ much in different individuals and species. Unfortunately, except in the rarest cases, it is impossible to obtain information as to the duration of life in wild animals. Enquiry into the frequency of death in domesticated

animals, or in animals in captivity, is therefore of scientific and practical interest. From the scientific point of view, it is the only mode of getting any kind of information as to constitutional differences in longevity and viability. From the practical point of view, it is the only way of judging of the effect on duration of life of the different kinds of environment to which animals may be subjected. There exists as yet very little recorded information, and I hope that this memoir may at least stimulate enquiry and make possible the collection and comparison of data.

The normal annual death-rate of the human inhabitants of London is about 14 or 15 per thousand, or 1.5 per cent. per annum, that is to say for every two hundred inhabitants there are about three deaths in the year. There is no census of the sparrow population of London, but the numbers of these hardy birds do not appear to increase or decrease in any marked way. Now a pair of sparrows may rear two or three clutches in the course of the year, each clutch having five or six eggs. If every pair of sparrows alive in London at the beginning of the breeding-season displayed maximum fertility, a death-rate of about 90 per cent. per annum would be necessary to keep the sparrow population stationary. No doubt many sparrows fail to mate successfully, but, judging from the numbers of young birds, it seems highly probable that the annual produce is at least a hundred per cent., which implies a normal death-rate, in a stationary population, of at least 50 per cent. On January 1, 1910, the number of vertebrate animals in our Gardens was 3186, and during the year, 2354 were added to the collection, making a total population of 5540. In the same period there were 1554 deaths, that is to say, the death-rate was about 28 per cent. Here, then, are three widely different rates, an actual percentage of 1.5 in the case of human beings, an estimated percentage of 50 in sparrows, and an observed percentage of 28 in the assemblage of vertebrates in the London Zoological Gardens. It is plain that the rates are not comparable; two of them refer to particular species, the third is a composite made up from many different species of mammals, birds, reptiles, batrachians, and fishes, each with their own different rates. The composite percentage is an arithmetical figure as meaningless as would be the sum of so many cows, coins and cabbages. Even in the case of a single species, however, a generalized death-rate is complex and misleading. The human death-rate is nearly 20 per cent. in the first year of life, falls rapidly for the first two or three years, and then more slowly till it reaches a minimum, and then gradually rises as advanced age is reached. The tables of "expectation of life," calculated for the Life Assurance Companies, show that the male infant under a year old has an expectation of 41 years, that this expectation rises to a maximum of 51 in the fourth year, and then gradually and almost without irregularity decreases until the age of one hundred years has been attained. It is clear that in the case of the vast majority of animals, and

notably in the case of wild animals that have been captured and brought into captivity, we have but vague materials for the construction of tables of expectation of life or for attaching any value to death-rates. We know roughly that there is an infantile period of low viability from the close of which through the periods of youth, maturity and senescence, there is a gradually decreasing expectation of life. But there are very few cases in which the durations of these periods or the potential duration of the whole life are known accurately, and still fewer cases in which the position of any single individual on its cycle of life can be determined accurately by physical signs, at least in the living animal. At present there is not enough knowledge on these matters to render possible the construction of any standards against which particular cases could be measured.

Fortunately there remains a mode of estimating the durations of life in a collection of animals which affords some indications of the total effect of the environment on the duration of life. In 1870 Sir Ray Lankester * (whose intellectual acumen has unravelled so many tangles in biology) drew some important distinctions in the significance of the word longevity. Strictly speaking, longevity denotes the duration of life of an individual; in practice, the word connotes some idea of relatively long duration and is used to indicate the duration of a life that has extended to its natural limit. A further distinction is necessary. The natural limit to the longevity of the individuals of a species may be taken to mean the average age attained by the normal members of a species living under the conditions to which they have become adapted by nature. The specific longevity would be the expectation of life at birth of a normal individual of the species. It is determined partly by the constitution, but still more by the accidents, enemies, diseases, and other external conditions to which the members of the species are naturally subject in every stage of their existence, and it is modified by the powers of evasion, protection, and resistance which they have acquired. On the other hand, it is possible to suppose that a member of a species, by good fortune or by artificial interference, has been removed from the hardships natural to its lot, and placed in an environment relatively ideal; under such conditions it would survive the specific longevity and attain an age which Lankester called the potential longevity. If we regard the population of Great Britain as living in an environment to which it has been naturally adapted, and the inhabitants of Great Britain as representing a species, then their specific longevity, the expectation of life at birth, is somewhere about 50 years. What the potential longevity is we do not know, but it is certainly more than a hundred years. The disparity is probably much greater in other cases. In the case of the sparrow the specific longevity, the expectation of life

* On Comparative Longevity in Man and the Lower Animals: London, 1870.

of the young sparrow when it is hatched, on the most favourable estimate cannot be more than one or two years; the potential longevity of small Passerine birds is certainly over 20 years.

The difference between the specific longevity and the potential longevity is a rough measure of the severity of the natural conditions under which a species lives, and a similar mode of comparison can be applied to assemblages of creatures living under different kinds of unnatural conditions. The object of this communication is in the first place to suggest a fashion in which a system of this kind could be employed usefully in Zoological Gardens, and in the second place to give the results of examination of a series of records regarding the duration of life of mammals and birds in captivity, which, although they are imperfect in many respects, are more extensive than any with which I am acquainted. The records in question are contained in two manuscript folios, kept in the Prosectorium of this Society and covering the period from 1870 to 1902. In these were entered day by day the names of the animals that had died in the Gardens, with the dates of their arrival and of their departure. From the point of view of estimating the effects of captivity on duration of life, they are defective in two important respects. In the first place, there is no record of the ages of the animals on arrival. This of course must always be impossible in the vast majority of cases, but two stages, the infantile and the senile, ought to be noted and excluded, where possible. Of these, the senile stage is usually easy to detect in the case of mammals, and it is at least probable that senile mammals are seldom purchased or accepted. On the other hand, senility in birds is extraordinarily difficult to detect, and the presence of such individuals will probably always confuse the record. The infantile period, corresponding to the first four years of human life, but of course varying greatly in its duration in different animals, is easy to detect; and as the difficulties of rearing infants are entirely different from the general problems of animals in captivity, infants should be excluded from records such as those with which I am dealing. In a number of cases, but not in all, I have been able to discard "infantile" entries. The second important defect in the statistics is that they do not include any note of the condition of the animals on arrival. Owing to the mode of capture, and still more to the conditions of transport, a large number of wild animals arrive at Zoological Gardens in poor condition, and die from causes not due to their new environment. For the kind of investigation I am now discussing (as of course for other reasons) new arrivals ought to be kept in quarantine. The duration of the quarantine need not be for a fixed period, but should be long enough to make certain that there has been recovery from the effects of capture and transport, and the date of detention in the Gardens should begin with that of liberation from quarantine.

With these comments I shall now pass to examination of the records, which however imperfect afford a considerable body of information*.

MAMMALIA †.

QUADRUMANA.

Family SIMIIDÆ.	Number of Individuals.	Average duration, in months.	Maximum duration, in months.
<i>Anthropopithecus troglodytes</i> (Chimpanzee).	20	8	46
<i>A. calvus</i>	2	61	94
<i>A. gorilla</i> (Gorilla)	2	3·5	5
<i>Simia satyrus</i> (Orang)	20	5·5	21
<i>Hylobates</i> (Gibbon), whole genus...	39	9	51
<i>H. hoolock</i>	9	17	51
<i>H. lar</i>	16	4·5	12
<i>H. agilis</i>	2	5·5	9
<i>H. leuciscus</i>	6	9·1	29
<i>H. leucogenys</i>	1	7	7
<i>H. muelleri</i>	2	2·5	4
<i>H. pileatus</i>	1	6	6
<i>H. syndactylus</i>	1	9	9
<i>H. hainanus</i>	1	13	13

We know that the figures in the third column are very much below the potential longevities of these animals, whilst the differences between the second and third columns are equally notable. It cannot be doubted that the conditions during the period in question were unfavourable to anthropoid apes. In 1901, after the period to which these figures relate, the existing house for Anthropoid Apes was completed. The new conditions differed from the old in providing more space, better ventilation, and protection from improper feeding by the public. These changes have been beneficial; in the case of the chimpanzee, of the orang and of the gibbon, there is at present alive in the Gardens at least one individual that has lived longer with us than the longest-liver of the previous period. On the other hand, the average duration has not risen notably. These animals must be regarded as of relatively low viability, a conclusion perhaps less surprising if it

* Since this paper was written I have seen the extremely interesting "List of Animals," living in the Zoological Gardens at Giza, near Cairo, 2nd Edition, and published in 1910. The author, Capt. Stanley S. Flower, has made the useful innovation of inserting opposite each species a note of the maximum ascertained length of life of an individual specimen in the Gardens. I have added to my paper some of Capt. Flower's records, but as these cover a period of only 12 years, higher maximums were impossible; if he were to publish average durations and state the general conditions of captivity of the different species, the work would be invaluable.

† The names used in this memoir, as far as possible, are those employed in the ninth edition of the "List of Vertebrated Animals now or lately living in the Gardens of the Zoological Society of London"; I have used Trouessart for determining synonyms.

be remembered that the lower races of man are of lower viability than the civilized races. None the less, existing results are so bad, that drastic experiments would be justified. The simplest change would be to allow them free access to the open air.

CERCOPITHECIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Semnopithecus</i> , whole genus	56	4·3	15
<i>S. entellus</i> (Langur)	20	4·6	13
<i>S. cephalopterus</i>	24	3·6	15
<i>S. fasciatus</i>	1	2	2
<i>S. maurus</i>	8	4	15
<i>S. obscurus</i>	2	12·5	14
<i>S. hypoleucus</i>	1	3	3

Here again it is plain that the conditions are hostile, and that these monkeys have a low viability. In the natural condition they feed chiefly on grain, and green leaves and shoots, and it is probable that their diet in captivity is not sufficiently bulky in proportion to its nutritive value. But these monkeys have always been treated as requiring warmth rather than fresh air.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Colobus</i> , various species, chiefly <i>vellerosus</i>	10	3·2	13

The African *Colobus* and *Guereza* monkeys resemble the Asiatic *Semnopithecus* in structure and habits. They appear equally to suffer from the conditions of captivity.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cercopithecus</i> ,* whole genus	693	11·5	122
<i>C. diana</i>	42	13	45
<i>C. neglectus</i>	1	40	40
<i>C. leucampyx</i>	19	9	44
<i>C. nictitans</i>	17	8	30
<i>C. martini</i>	13	22	122
<i>C. labiatus</i>	1	17	17
<i>C. stairsi</i>	4	8	12
<i>C. albogularis</i>	45	11	46
<i>C. grayi</i>	6	12	41
<i>C. mona</i>	28	17	65
<i>C. campbelli</i>	27	12·9	76
<i>C. lhoesti</i>	1	44	44
<i>C. petaurista</i>	39	11·7	66
<i>C. ascanias</i>	2	7	11
<i>C. schmidti</i>	2	3	5
<i>C. cephus</i>	37	17·7	65
<i>C. erythrotis</i>	2	33·5	47

* In this genus, I have followed as nearly as possible the synonymy in Mr. R. I. Pocock's revision, P. Z. S. 1907, p. 677.

CERCOPITHECIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cercopithecus sabæus</i> (= <i>callitrichus</i>)	109	7	43
<i>C. æthiops</i> (= <i>griseo-viridis</i>)	24	14	60
<i>C. cynosurus</i>	59	13	87
<i>C. tantalus</i>	5	15	37
<i>C. pygerythrus</i> (= <i>lalandii</i>)	146	8·6	59
<i>C. talapoin</i>	15	13·8	34
<i>C. patas</i>	40	6·9	27
<i>C. pyrrhonotus</i>	9	5·5	16
<i>Cercocebus</i> , whole genus..... (Mangabey.)	85	12·2	48
<i>C. æthiops</i>	15	7·5	48
<i>C. albigena</i>	15	10·3	42
<i>C. aterrimus</i>	1	5	5
<i>C. collaris</i>	15	12	38
<i>C. chrysogaster</i>	1	12	12
<i>C. fuliginosus</i>	36	16	40
<i>C. hagenbecki</i>	2	8	10

The Cercopithecues and Mangabeys for the very large number of individuals recorded thus show an average duration of about one year; the best record, about ten years, must be taken as far below the potential longevity of the group, and it is clear that the conditions of captivity press hardly on them. Throughout the period in question, they were treated as animals which must be protected against cold, and they were allowed no access to the open air.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Macacus</i> , whole genus	910	14	143
(Macaques.)			
<i>M. assamensis</i>	1	5	5
<i>M. brunneus</i>	5	12·8	22
<i>M. cyclopis</i>	2	20	26
<i>M. cynomolgus</i>	328	16·5	130
<i>M. lasiotus</i>	3	28·6	41
<i>M. leoninus</i>	7	18	27
<i>M. nemestrinus</i>	58	20	62
<i>M. pelops</i>	3	10	16
<i>M. pileatus</i>	21	10	27
<i>M. rhesus</i>	212	16·6	143
<i>M. tcheliensis</i>	3	5·3	7
<i>M. silenus</i>	16	30	119
<i>M. sinicus</i>	203	13	75
<i>M. speciosus</i>	4	41	104
<i>M. maurus</i>	7	18	73
<i>M. arctoides</i>	2	16·5	19
<i>M. rufescens</i>	2	8	15
<i>M. ocreatus</i>	9	11	28
<i>M. inuus</i>	24	12·3	38

The large number of Macaque monkeys recorded shows the same low average duration, and the same marked difference between the average and the maximum duration, although the latter is certainly below the potential longevity. A Common Macaque occasionally deposited temporarily at the Gardens is stated by its owner to be at least 22 years old. It is of significance that the highest average relates to Japanese apes, examples of which, unlike all the others, were housed in a cage exposed to the open air.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cynopithecus niger</i>	9	10	41
(Celebes Black Ape.)			
All Baboons	137	12.2	113
<i>Theropithecus gelada</i>	2	9.5	10
<i>Cynocephalus anubis</i>	12	12.6	51
<i>C. babouin</i>	19	10	113
<i>C. doguera</i>	1	4	4
<i>C. hamadryas</i>	22	12	29
<i>C. ibeanus</i>	1	1	1
<i>C. leucophaeus</i>	6	16	26
<i>C. mormon</i>	7	15	25
<i>C. neumanni</i>	1	7	7
<i>C. papio</i>	2	3	6
<i>C. porcarius</i>	43	12	50
<i>C. sphinx</i>	21	15	41

Baboons, on the average, show even a lower duration and a greater difference between the average and the potential longevity than Macaques. Since the period in question, a number of baboons have been exposed to the air and the average duration is notably higher.

CEBIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Chrysothrix sciurea</i>	44	9	108
(Squirrel Monkey.)			
<i>Cebus</i> , whole genus	226	10	50
(Capuchins.)			
<i>C. albifrons</i>	33	8.6	20
<i>C. apella</i>	10	11.8	27
<i>C. azaræ</i>	2	11	16
<i>C. capucinus</i>	39	7.5	20
<i>C. fatuellus</i>	58	11.8	50
<i>C. flavescens</i>	6	8.5	12
<i>C. hypoleucus</i>	46	8	17
<i>C. lunatus</i>	9	17	39
<i>C. monachus</i>	21	14.3	42
<i>C. vellerösus</i>	1	15	15
<i>C. versicolor</i>	1	31	31

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Ateles</i> , whole genus	107	5·8	27
(Spider-monkeys.)			
<i>A. ater</i>	54	4·5	27
<i>A. geoffroyi</i>	10	7·9	24
<i>A. griseus</i>	1	2	2
<i>A. hybridus</i>	1	9	9
<i>A. melanochir</i>	31	8	20
<i>A. paniscus</i>	4	5·2	10
<i>A. rufiventris</i>	2	3	4
<i>A. variegatus</i>	3	4·6	11
<i>A. vellerosus</i>	1	3	3
<i>Lagothrix humboldti</i>	14	5·2	16
<i>Nyctipithecus</i> , whole genus	27	13	45
(Douroucoulis.)			
<i>N. felinus</i>	14	13	45
<i>N. rufipes</i>	1	1	1
<i>N. trivirgatus</i>	2	5	5
<i>N. vociferans</i>	10	15·5	28
<i>Callithrix</i> , whole genus	5	4	8
(Teetees.)			
<i>Pithecia</i> , whole genus	16	2·7	7
<i>Ouacaria</i> , whole genus	7	3·5	11
<i>Mycetes</i> , whole genus	9	3·6	13

The Cebidæ show the same marked disparity between the average duration and the maximum duration, although again the latter must be considerably less than the potential longevity. It is interesting to notice that the Capuchins and Squirrel Monkeys display a higher viability than the others.

HAPALIDÆ. (Marmosets.)	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hapale</i> , whole genus	232	3·8	16
<i>H. chrysoleucos</i>	1	7	7
<i>H. jacchus</i>	134	4·2	16
<i>H. melanura</i>	1	6	6
<i>H. penicillata</i>	94	3·4	16
<i>H. pygmæa</i>	2	2·5	5
<i>Midas</i> , whole genus	103	6	110
<i>M. chrysomelas</i>	2	6·5	11
<i>M. geoffroyi</i>	7	2·4	4
<i>M. labiatus</i>	1	4	4
<i>M. mystax</i>	1	5	5
<i>M. ædipus</i>	25	4	14
<i>M. rosalia</i>	39	9	110
<i>M. rufimanus</i>	11	4·5	16
<i>M. ursulus</i>	17	4·6	12

Amongst the numerous Marmosets dealt with in the record, a

single case of relatively high longevity, that of a Lion Marmoset which lived in the Gardens for over 9 years, has given those of the genus *Midas* an average duration of nearly double that of the representatives of *Hapale*. Even this fortunate instance, however, does not disguise the low viability of Marmosets under the conditions of their captivity. As these animals spend a large part of their time in their sleeping boxes, unwise feeding by visitors cannot account for much. On the other hand, they have been treated as animals that required special protection from cold and fresh air.

Miss C. Morey informs me that she has kept a marmoset for 16 years; it was allowed great freedom and had constant access to fresh air.

LEMURES.

LEMURIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Lemur</i> , whole genus	155	25·3	134
<i>L. albifrons</i>	16	43·6	113
<i>L. albimanus</i>	1	36	36
<i>L. brunneus</i>	22	25	98
<i>L. catta</i>	33	19	38
<i>L. coronatus</i>	10	19·5	55
<i>L. flavifrons</i>	1	45	45
<i>L. macaco</i>	17	46	134
<i>L. mayottensis</i>	1	2	2
<i>L. mongoz</i>	7	39	122
<i>L. niger</i>	3	63	107
<i>L. nigerrimus</i>	2	30·5	43
<i>L. nigrifrons</i>	3	23	46
<i>L. rufifrons</i>	13	27	113
<i>L. rufipes</i>	3	22	29
<i>L. varius</i>	10	20·9	77
<i>L. xanthomystax</i>	13	29	72
<i>Hapalemur simus</i>	2	5·5	8
<i>H. griseus</i>	6	22	58
<i>Chirogaleus coquereli</i>	8	82	184
<i>C. milii</i>	2	70	138
<i>Microcebus smithi</i>	14	20	84
<i>Galago</i> , whole genus	61	22	86
<i>G. alleni</i>	3	9	15
<i>G. crassicaudata</i>	7	16	34
<i>G. garnetti</i>	20	17·5	43
<i>G. maholi</i>	25	26·7	78
<i>G. montieri</i>	6	32	86
<i>Nycticebus javanicus</i>	1	21	21
<i>N. tardigradus</i>	29	13	49
<i>Loris gracilis</i>	12	3·4	7
<i>Perodicticus potto</i>	18	9·3	22
<i>Chiromys madagascariensis</i>	3	36·3	107

With the exception of the Loris and the Potto, the Lemurs show a longer average duration and a higher maximum duration than in the case of Monkeys. There still remains, however, a very marked discrepancy between the average duration and the maximum duration, although the latter must be regarded as much below the probable potential longevity. On the whole, lemurs have been kept under conditions not very different from those of the monkeys. It is probably in their favour that as they are more nocturnal than monkeys, they have escaped to a greater extent erroneous feeding by the public, whilst as they are on the whole more strictly arboreal than monkeys, the relative absence of light and the more equable temperature in the interior of warmed houses have not been so damaging to them. On the other hand, they are, on the average, smaller than monkeys, and as within the same group smaller animals have usually shorter lives than larger animals, a longer average duration and a higher maximum duration as compared with monkeys, was not to be expected.

Summary of Quadrumana.

It is well known that the higher races of men have a higher viability than the lower races; that is to say, they display a greater power of resistance to adverse conditions, to changed conditions, and to diseases (although not necessarily to any particular disease). It is of interest to find that a still lower viability is exhibited by apes and monkeys which as a group have an amazingly poor power of resistance to the adverse conditions of captivity. It is even more interesting to note that there is a marked gap between monkeys and lemurs in this respect. The fact that the latter on an average live four or five times as long in captivity as monkeys, shows a marked difference in their constitutions. I may recall a curious by-product of an investigation into the feeding of snakes made by my friend and colleague Mr. R. I. Pocock and myself (P. Z. S. 1907, p. 785), when we found that lemurs differed from monkeys in having no fear of snakes. Fundamental differences between groups are revealed not only by anatomical characters, and in view of the present tendency to lay increasing stress on the anatomical links between lemurs and other primates, I think their physiological differences are worth some attention. There is, however, another interpretation of the higher viability of lemurs in captivity. The close affinity of man and monkeys may render the latter more subject to human diseases and therefore more liable to suffer from the vicinity of man. Such a question can be answered only by long records of the causes of mortality based on adequate diagnosis. The laborious work of my friend and colleague Mr. H. G. Plimmer, unfortunately does not extend back to the period with which my present inquiry deals.

Even if it be accepted that apes, monkeys, and lemurs are creatures of inherently low powers of resistance, the striking difference between the average durations and the maximum

durations makes it clear that they have been subjected to adverse conditions. Throughout the period to which the figures relate, and in a majority of cases since, the conditions of their housing have been determined by considerations of temperature rather than of fresh air. The conclusion is inevitable that these conditions are adverse. This is not the place to discuss the construction of houses for animals, but it may be well to say that there is no reason to suppose that the other extreme, complete indifference to the provision of warmth; would be much better, although it could not be much worse.

Capt. Stanley Flower's records show no figures of maximum duration greater than those recorded here.

CARNIVORA.

FELIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Felis leo</i> (Lion)	53	45·4	204
<i>F. tigris</i> (Tiger)	30	44·2	145
<i>F. pardus</i> (Leopard)	52	39·9	164
<i>F. uncia</i> (Snow-leopard)	2	20·5	40
<i>F. lynx</i> (Lynx)	8	57	169
<i>F. rufa</i> (Bay Lynx)	3	55	122
<i>F. canadensis</i> (Canadian Lynx) ...	2	73	139
<i>F. caracal</i> (Caracal)	9	63	131
<i>F. concolor</i> (Puma)	18	41·2	124
<i>F. onca</i> (Jaguar)	8	33·5	123

I have omitted from these figures a certain number of entries of under one month and which, in most cases, related to very young animals or new-born cubs. The highest record in the period, 17 years, in the case of a Lion, is certainly very much under the potential longevity of the group, for lions of between 30 and 40 years old have been known. The discrepancy between the average duration and the maximum duration is still great, but very much less serious than in the case of apes and monkeys, and considerably less than in the case of lemurs. Capt. Stanley Flower gives no higher records.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>F. nebulosa</i> (Clouded Tiger).....	1	62	62
<i>F. serval</i> (Serval)	22	21·7	98
<i>F. servalina</i> (Servaline Cat)	5	9	45
<i>F. temmincki</i> (Golden Cat)	4	24	65
<i>F. viverrina</i> (Viverrine Cat).....	4	51	112
<i>F. bengalensis</i> (Bengalese Cat).....	22	16	77
<i>F. planiceps</i> (Rusty Tiger Cat) ...	2	5	5
<i>F. rubiginosa</i> (Rusty Spotted Cat).	2	1·5	2
<i>F. chrysothrix</i> (Red Tiger Cat).....	1	1	1
<i>F. catus</i> (Wild Cat)	31	15	110
<i>F. chaus</i> (Jungle Cat)	15	47	118

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Felis caffra</i> (Kaffer Cat)	3	1	2
<i>F. maniculata</i> (Fettered Cat)	2	17·5	35
<i>F. yaguarundi</i> (Yaguarundi Cat)...	5	1	3
<i>F. eyra</i> (Eyra Cat).....	10	19	109
<i>F. pardalis</i> (Ocelot)	56	17	152
<i>F. tigrina</i> (Tigrine Cat)	4	3	5
<i>F. geoffroyi</i> (Geoffroy's Cat)	10	17·8	103
<i>F. passerum</i> (Pampas Cat)	2	8	10

The records of average and maximum duration of these smaller Cats are very irregular, and in many cases the numbers are too small for the result to be more than accidental. We do not know what is the potential longevity of the smaller cats; it may be expected to be less than that of large cats, and has been estimated at something over twenty years. It is clear that the difference between average duration and potential duration has been much greater in the case of the small cats than in that of the large cats. The domestic cat is notoriously a hardy animal, and I should hesitate to infer a lower viability for small cats than for large cats. In the first place, throughout the period under discussion, the majority of the large cats were kept in the Lion House, a building in which the ventilation and bulk of air per inhabitant were fairly good, whilst, although there was not free communication with the outer air, there were outdoor cages, to which on occasion the animals had access. The smaller cats, on the other hand, were kept in a smaller and darker house, with much less ventilation, more heating, and no access to the open air. In the second place, there is an important natural difference with regard to feeding, which has not been allowed for systematically. The larger cats are accustomed to make an occasional kill, and to return to a carcase even after it is putrid. The smaller cats, on the other hand, devour their smaller prey as soon as they have killed it, and unless under the pressure of serious hunger, take nothing except quite fresh food. In accordance with their natural habits, the larger cats are little injured by food which is not quite fresh, whilst the smaller forms are highly susceptible to intestinal ailments arising from the quality of their food. I am convinced that the necessity for extreme care in the quality of food given to the smaller cats has not been sufficiently realized.

I do not think there can be any doubt, however, that both with smaller and larger Felidæ, the necessity of access to the open air, at the choice of the animals, has not been appreciated, and that the low viability under menagerie conditions is due to this neglect. Most of them are partly nocturnal, many of them cover a wide climatic range, and as in many, if not all furred animals, the thickness and length of their coat increase rapidly with exposure to low temperatures. No doubt provision for basking in the sun, or for warming themselves in artificially-heated retreats, is

necessary in most cases, but even more necessary is constant access to the open air, by night and by day, at the free choice of the animals.

FELIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cynelurus jubatus</i> (Cheetah)	17	30	78
<i>Cryptoprocta ferox</i> (Cryptoprocta) ...	2	4.5	5

Capt. Stanley Flower records a duration of over 9 years for a Cheetah, the animal being still alive.

VIVERRIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Viverra</i> , whole genus	19	65	181
<i>V. civetta</i> (African Civet)	14	66	181
<i>V. tangalunga</i> (Sumatran Civet)	4	40	81
<i>V. zibetha</i> (Large Indian Civet)	1	143	143
<i>Viverricula</i> , whole genus	12	33.5	93
<i>V. malaccensis</i> (Indian Civet)	11	34.5	93
<i>V. schlegeli</i> (Schlegel's Civet)	1	23	23

We have no information as to the potential longevity of Civets, but the record of 15 years is no doubt considerably too short. On the other hand, their average duration of life has been good; it is interesting to notice that, although these are at least as typically tropical animals as the majority of the Felidæ, they have been for the most part kept out of doors in unwarmed shelters.

<i>Genetta</i> , whole genus	46	30	148
<i>G. felina</i> (Feline Genet)	2	16	16
<i>G. pardina</i> (Pardine Genet)	4	47.5	148
<i>G. senegalensis</i> (Pale Genet)	4	8	17
<i>G. tigrina</i> (Blotched Genet)	22	35	122
<i>G. vulgaris</i> (Common Genet)	14	27	101
<i>Paradoxurus</i> , whole genus	58	35	185
<i>P. aureus</i> (Golden Paradoxure)	3	16	35
<i>P. grayi</i> (Gray's Paradoxure)	3	55	99
<i>P. niger</i> (<i>P. prehensilis</i> , <i>P. pallasi</i> , <i>P. hermaphroditus</i>) (Common Paradoxure).	35	25.8	111
<i>P. larvatus</i> (Masked Paradoxure).....	8	64	185
<i>P. leucomystax</i> (White-whiskered Para- doxure).	4	53	166
<i>P. philippensis</i> (Philippine Paradoxure)	5	28	102
<i>Arctogale leucotis</i> (Three-striped Para- doxure).	8	40	132
<i>A. trivirgata</i>	1	5	5
<i>Hemigalea hardwickii</i> (Hardwicke's Hemigale).	2	5.5	7
<i>Arctictis binturong</i> (Binturong)	8	39	82

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Nandinia binotata</i> (Two-spotted Paradoxure).	16	32	85
<i>Galidia elegans</i> (Elegant Galidia)	2	4.5	9
<i>Herpestes</i> , whole genus	152	20.8	105
<i>H. albicauda</i> (White-tailed Ichneumon)	3	31.3	75
<i>H. fulvescens</i> (Maccarthy's ")	4	15	20
<i>H. galera</i> (Marsh ")	9	31	57
<i>H. gracilis</i> (Slender ")	5	17.4	35
<i>H. griseus</i> (Grey ")	70	14	53
<i>H. ichneumon</i> (Egyptian ")	15	40	91
<i>H. auro-punctatus</i> (Spotted ")	30	18	57
<i>H. pulverulentus</i> (Dusty ")	7	47	105
<i>H. smithi</i> (Ruddy ")	9	22	35
<i>Cynictis penicillata</i> (Levaillant's Cynictis).	18	32	145
<i>Crossarchus obscurus</i> (Kusimanse) ...	5	15.6	49
<i>C. fasciatus</i> (Banded Ichneumon).....	24	32.8	92
<i>Suricata tetradactyla</i> (Suricate).....	45	12.6	58

The Genets, Paradoxures, Ichneumons, and Suricates are small carnivores varying in their diet from purely carnivorous (including small mammals, birds, reptiles, eggs, insects) to a mixed and partly frugivorous or vegetarian type. What their potential longevity may be is quite unknown, but the records of maximum duration going to over fifteen years are unexpectedly high for these small animals. The average duration varies very much, but is lower than in the case of the civets. During the period covered by the records, the genets, paradoxures, etc., unlike the civets, have been kept in most cases in a warmed house, without access to the open air.

Capt. Stanley Flower has no higher records.

PROTELIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Proteles cristatus</i> (Aard-Wolf)	6	53	155

We have no information as to the potential longevity of this aberrant animal, but it appears to have a high viability.

HYÆNIDÆ.

<i>Hycæna</i> , whole genus	43	29.5	160
<i>H. brunnea</i> (Brown Hyæna)	5	30.2	56
<i>H. crocuta</i> (Spotted ")	11	58.7	160
<i>H. striata</i> (Striped ")	27	17.6	74

Nothing is known as to the potential longevity of hyænas, and the record of 13 years in the Gardens may possibly be a fair age for these animals. They have been kept at the Gardens in cages under cover, exposed on one side to the open air and provided

with hot-water pipes. They have had little room for exercise. The lower viability of the striped species is difficult to explain. Capt. Stanley Flower quotes a Spotted Hyæna and a Striped Hyæna, each with a duration of over 10 years, and still alive.

CANIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Canis lupus</i> (Common Wolf)	18	29	72
<i>C. hodophylax</i> (Japanese „)	1	90	90
<i>C. pallipes</i> (Indian „)	5	42	149
<i>C. latrans</i> (Prairie „)	4	59	115
<i>C. antarcticus</i> (Antarctic „)	2	41·5	64
<i>C. niger</i> (Black „)	2	75	90
All Wolves	32	40	149
<i>C. anthus</i> (North-African Jackal).....	36	13·3	82
<i>C. aureus</i> (Common „).....	16	22·4	122
<i>C. lateralis</i> (Side-striped „).....	8	24	56
<i>C. mesomelas</i> (Black-backed „).....	39	19	164
All Jackals	99	18	164
<i>C. dingo</i> (Dingo).....	11	43	145
<i>C. (Cuon) primævus</i> (Indian Wild Dog) 6	35	55	
<i>C. (Cuon) rutilans</i> (Malay Wild Dog) . 4	22	28	
<i>C. jubatus</i> (“Maned Wolf”)	2	15·5	23
<i>C. azaræ</i> (Azara's Dog)	19	35	103
<i>C. cancrivorus</i> (Crab-eating Dog)	19	15	60
<i>C. magellanicus</i> (Magellanic Dog).....	4	32	100
<i>C. fulvicaudus</i> (Red-tailed Dog)	1	53	53
<i>C. fulvipes</i> (Red-footed Dog).....	1	16	16
<i>C. (Nyctereutes) procyonoides</i> (Raccoon Dog).....	13	26	69
<i>C. microtis</i> (Small-eared Dog)	1	4	4
All fox-like Dogs	58	27	103
<i>C. argentatus</i> (Silver Fox)	1	48	48
<i>C. bengalensis</i> (Bengal Fox)	12	21	68
<i>C. cerdo</i> (Fennec Fox)	10	24·9	110
<i>C. chama</i> (Silver-backed Fox)	15	19	62
<i>C. famelicus</i> (Syrian Fennec)	5	14·4	32
<i>C. fulvus</i> (Red Fox)	21	30	97
<i>C. lagopus</i> (Arctic Fox)	24	48·8	132
<i>C. leucopus</i> (Indian Desert-Fox)	6	50	91
<i>C. niloticus</i> (Egyptian Fox)	9	32·5	77
<i>C. pallidus</i> (Pale Fennec Fox)	5	15	60
<i>C. velox</i> (Kit Fox)	5	34	71
<i>C. virginianus</i> (Virginian Fox).....	11	12·6	30
<i>C. vulpes</i> (Common Fox)	41	14·6	87
All Foxes and Fennec Foxes.....	165	26·7	132
<i>Lycæon pictus</i> (Cape Hunting-Dog) ...	6	19·3	56
<i>Icticyon venaticus</i> (Bush-dog)	1	2·5	4
<i>Otocyon megalotis</i> (Long-eared Fox) ...	4	4·5	8

The potential longevity of Canine animals is probably not much

more than thirty years. Ray Lankester * has recorded a domestic dog of 34 years; the oldest Metchnikoff was able to procure was 22 years and was very decrepid. The maximum record in this list—a Jackal which lived in the Gardens for nearly fourteen years, but the age of which on arrival is unrecorded,—is, therefore, not at all unexpected. The viability varies roughly with size, the wolves having a better average than jackals, small wild dogs and foxes. Within the period recorded, so far as I can ascertain, the wolves have been freely exposed to the open air, whilst many, although not all, of the smaller animals have been provided with artificial heat.

Capt. Stanley Flower has no higher records.

MUSTELIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Mustela</i> , whole genus	38	29	123
<i>M. erminea</i> (Common Stoat)	7	21	39
<i>M. foina</i> (Beech-Marten)	5	48·4	84
<i>M. martes</i> (Pine-Marten)	7	27	107
<i>M. pennanti</i> (Canadian Marten)	1	123	123
<i>M. putorius</i> (Pole-cat)	11	10·6	26
<i>M. vulgaris</i> (Weasel)	7	38·7	94
<i>Gulo luscus</i> (Glutton)	6	42	64
<i>Galictis barbara</i> (Tayra)	13	30	95
<i>G. vittata</i> (Grisson)	12	41	117
<i>Ictonyx frenata</i> (Banded Zorilla)	1	2	2
<i>I. lybica</i> (Libyan Zorilla)	8	8·5	41
<i>I. zorilla</i> (Cape Zorilla)	18	15	65
<i>Helictis subaurantiaca</i> (Orange-bellied Helictis).	1	48	48
<i>Mellivora capensis</i> (Cape Ratel).....	1	208	208
<i>M. indica</i> (Indian Ratel)	1	152	152
<i>Taxidea americana</i> (American Badger) ..	2	130	145
<i>Meles ankuma</i> (Sand Badger)	3	79	152
<i>M. leptorhynchus</i> (Sharp-nosed Badger) ..	1	9	9
<i>M. taxus</i> (Common Badger)	26	32	137
All Badgers	32	41·5	152
<i>Mephitis mephitis</i> (Canadian Skunk) .	5	25	50
<i>Conepatus mapurito</i> (Chilian Skunk) .	5	21	49
<i>Lutra leptonyx</i> (Small-clawed Otter)...	2	7	10
<i>L. nair</i> (Indian Otter)	3	32	52
<i>L. vulgaris</i> (Common Otter)	36	40	87

The average and maximum durations of the various Musteline carnivores vary irregularly. The longest duration, 17 years for a Cape Ratel, is surpassed by an Indian Ratel which has been for 20 years in the Gardens and is still alive. It is clear that the potential longevity of the Mustelines is high, if their relatively

* Quoted by É. Metchnikoff, 'The Prolongation of Life,' English Translation. Heinemann, London, 1907.

small size be considered. The apparent low viability of many of these animals may be attributed partly to their fierce and active disposition, from which it comes about that captured animals are frequently young or feeble, and that after capture there is heavy mortality from fighting and injury. But there is a marked effect of the mode of housing; the rats and badgers have been kept in open-air enclosures, whilst a majority of the other forms have been housed in small cages in dark, warmed and badly-ventilated houses.

Capt. Stanley Flower has no higher records.

PROCYONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Procyon cancrivorus</i> (Crab-eating Raccoon).	10	68	190
<i>P. lotor</i> (Raccoon)	24	50	165
<i>Nasua narica</i> (White-nosed Coati) .	35	14	46
<i>N. rufa</i> (Ring-tailed Coati)	63	12.5	62
<i>Cercoptes caudivolvulus</i> (Kinkajou) .	30	30	75
<i>Bassaritis astuta</i> (Cunning Bassaris) .	5	10.6	29
<i>Bassaricyon alleni</i> (Allen's Bas- saricyon).	1	66	66

The Procyonidæ are another group regarding the potential longevity of which we have no information. The record of nearly 16 years for a Raccoon shows that the group in this respect resembles the larger mustelines. It is noteworthy that the average longevity of the Raccoons, which have been kept out of doors, is very much higher than that of the Coatis, which have been kept indoors.

ÆLURIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Ælurus fulgens</i> (Panda).....	2	32	64

URSIDÆ.

<i>Ursus</i> , whole genus.....	75	68.9	400
<i>U. americanus</i> (Black Bear).....	12	73	205
<i>U. arctos</i> (Brown ").....	20	23.6	133
<i>U. horribilis</i> (Grizzly ").....	1	164	164
<i>U. isabellinus</i> (Isabelline ").....	4	84	153
<i>U. japonicus</i> (Japanese ").....	2	109.5	123
<i>U. malayanus</i> (Malay ").....	5	91	247
<i>U. maritimus</i> (Polar ").....	8	102	400
<i>U. ornatus</i> (Spectacled ").....	2	96	163
<i>U. piscator</i> (Hairy-eared ").....	1	309	309
<i>U. syriacus</i> (Syrian ").....	8	107.6	259
<i>U. tibetanus</i> (Himalayan ").....	12	39	179
<i>Melursus ursinus</i> (Sloth Bear)	9	41	109

The duration of over 33 years attained by a Polar Bear may

possibly approach the potential longevity of bears, for the conditions provided, affording exercise, constant access to fresh air and to shelter, and regular food, must be more natural than in the case of most animals in captivity. The average duration of life of the bears is probably low on account of the number of cubs which are included and which had received unwise treatment as pets. Nevertheless, the average longevity is higher than in the case of any other large carnivora, and it is interesting to notice that during the period dealt with these animals, although not given good room for exercise, were freely exposed to the open air, and at the same time provided with some artificial heat.

Capt. Stanley Flower's records are much lower.

OTARIIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Otaria</i> , whole genus	6	108	210
<i>O. californiana</i> (Californian Sea-lion) .	1	51	51
<i>O. hookeri</i> (Hooker's ") .	2	18	34
<i>O. jubata</i> (Patagonian ") .	2	199	210
<i>O. pusilla</i> (Cape Sea-lion)	1	151	151
<i>Halichoerus gryphus</i> (Grey Seal).....	7	17	73
<i>Phoca vitulina</i> (Common Seal)	25	20	172
<i>Monachus albiventer</i> (Mediterranean Seal).	2	17	34
<i>Cystophora cristata</i> (Bladder-nosed Seal).	7	4.5	26

Sea-lions and Seals evidently at least equal in potential longevity other members of the order Carnivora of large size. The relatively low average duration is due to the very heavy mortality of young and newly caught animals. The greatest number of deaths are of animals that have lived only a few months in the Gardens; if they survive that period, and only a small proportion do survive it, their duration of life is very good. They have free access to open air, and no artificial heat.

Summary of Carnivora.

Carnivora are generally regarded as animals with relatively long lives and high viability, and the records given above support such a view. It is curious, moreover, how the maximum durations correspond roughly with the sizes of the animals. Bears reached 33 years, Lions and Tigers 17, Sea-lions 17, the smaller Cats 13, Viverrids 15, Hyænas 13, Jackals 13, Badgers 12, smaller Dogs and Foxes 10, Mustelines 10. On the other hand, comparison of average durations with maximum durations shows in the clearest way that those animals have lived best which have had the readiest access to fresh air, that, in fact, darkness and the bad air of heated houses are much greater dangers to life than cold.

INSECTIVORA.

SORECIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Crocidura cerulescens</i> (Bluish Shrew) .	1	1	1

ERINACEIDÆ.

<i>Erinaceus</i> , whole genus	53	10	54
<i>E. albinervis</i> (White-bellied Hedgehog)	1	1	1
<i>E. algirus</i> (Algerian Hedgehog)	3	28	35
<i>E. auritus</i> (Long-eared ")	8	12	24
<i>E. collaris</i> (Collared ")	6	19	54
<i>E. europæus</i> (European ")	33	7	20
<i>E. frontalis</i> (Cape ")	1	1	1
<i>E. micropus</i> (Small-footed ")	1	1	1

TUPAIIDÆ.

<i>Tupaia peguana</i> (Peguan Tree-Shrew)	1	22	22
<i>T. tana</i> (Tana Tupaia)	1	28	28

CENTETIDÆ.

<i>Centetes caudatus</i> (Tenrec)	11	10.5	24
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I do not know of any information as to the potential longevity of Insectivora, and the few records which I have found would appear to show that both the viability and the longevity of these animals under the conditions of captivity are bad. They have invariably been kept indoors, in small cages in houses heated in winter.

Capt. Stanley Flower's records are all low, the maximum being 34 months for a Long-eared Hedgehog.

CHIROPTERA.

PTEROPODIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pteropus</i> , whole genus	42	30	205
<i>P. formosus</i> (Formosan Fruit-bat).	3	62	94
<i>P. gouldi</i> (Gouldian ") .	1	58	58
<i>P. medius</i> (Indian ") .	30	27	205
<i>P. poliocephalus</i> (Australian ") .	6	22	83
<i>P. pselaphon</i> (Bonin ") .	1	26	26
<i>P. scapulatus</i> (Scapulatus ") .	1	7	7
<i>Cynonycteris collaris</i> (Collared Fruit-Bat).	13	18	108
<i>Cynopterus marginatus</i> (White-eared Fruit-Bat).*	4	24	30

Metchnikoff has already recorded from the London Zoological Gardens the case of maximum duration amounting to 17 years in a Fruit-bat, and has pointed out that the probable maximum longevity of such bats is high. The records show that the viability under existing conditions is not good, as wherever there is a

considerable number of specimens, the average duration is much below the maximum duration. There is no difficulty about feeding these animals, but they have always been treated as creatures requiring protection from cold and indifferent to fresh air.

Capt. Stanley Flower records a Collared Fruit-bat of over 11 years' duration and still alive.

VESPERTILIONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Vespertilio noctula</i> (Great Bat) ...	10	1·9	5
<i>V. nattereri</i> (Natterer's Bat)	12	1	1
<i>Plecotus auritus</i> (Long-eared Bat) .	11	·09	1

Bats are popularly supposed to be long-lived animals, but these records show only the complete failure to keep them in captivity. The chief difficulty has been to induce them to feed.

RODENTIA.

SCIURIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sciurus</i> , whole genus	273	15·5	181
<i>S. æstivans</i> (Tropical Squirrel) ...	2	22·5	41
<i>S. arizonensis</i> (Arizona „) ...	1	39	39
<i>S. atrodorsalis</i> (Dark-backed „) ...	1	10	10
<i>S. bicolor</i> (Jelerang „) ...	4	10·5	23
<i>S. caniceps</i> (Hoary-headed „) ...	1	114	114
<i>S. castaneiventris</i> (Chestnut-bellied Squirrel).	2	71	107
<i>S. cinereus</i> (Grey Squirrel)	24	48·7	181
<i>S. ephippium</i> (Saddled „)	1	64	64
<i>S. erythropus</i> (White-banded Squirrel)	2	13·5	15
<i>S. griseus</i> (Western Grey „)	3	25	40
<i>S. griseo-flavus</i> (Guatemala „)	1	34	34
<i>S. hudsonius</i> (Hudson-Bay „)	9	40·5	99
<i>S. hypopyrrhus</i> (Dorsal „)	20	34·4	89
+ <i>dorsalis</i> .			
<i>S. ludovicianus</i> (Yellow-footed „)	2	29·5	56
<i>S. macrurus</i> (Grizzled Hill „)	2	13·5	19
<i>S. madagascariensis</i> (Madagascar „)	1	4	4
<i>S. maximus</i> (Malabar „)	19	21·5	75
= <i>indicus</i> .			
<i>S. nigro-vittatus</i> (Malayan „)	1	34·5	68
<i>S. palmarum</i> (Palm „)	35	3·2	14
<i>S. plantani</i> (Plantain „)	15	22	53
<i>S. prevosti</i> (Prevost's „)	8	13·5	34
<i>S. pusillus</i> (Dwarf „)	2	8·5	12
<i>S. pygerythrus</i> (Blanford's „)	1	2	2
<i>S. stramineus</i> (Fraser's „)	2	8	8
<i>S. syriacus</i> (Syrian „)	3	59	69
<i>S. tennenti</i> (Tennent's „)	5	25·4	42
<i>S. tristriatus</i> (Three-striped „)	4	3·5	5

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sciurus variabilis</i> (Variable Squirrel)	2	73	75
<i>S. variegatus</i> (Red-bellied „)	13	36	129
<i>S. vulgaris</i> (Common „)	77	6	20
<i>S. vulpina</i> (Vulpine „)	10	36	85
<i>Xerus</i> , whole genus	24	9.8	41
<i>X. erythropus</i> (Red-footed Ground Squirrel).	7	8	19
<i>X. getulus</i> (Getulian Ground Squirrel).	11	10.5	41
<i>X. setosus</i> (Bristly Ground Squirrel).	6	10	15
<i>Tamias</i> , whole genus	16	26	84
<i>T. asiaticus</i> (Asiatic Ground Squirrel)	3	8	23
<i>T. lateralis</i> (Side-striped „ „)	1	21	21
<i>T. striatus</i> (Chipping Squirrel)	12	31	84
<i>Pteromys</i> , whole genus	5	61	163
<i>P. albo-rufus</i> (Red-bellied Flying-Squirrel).	1	163	163
<i>P. inornatus</i> (Large Red Flying-Squirrel).	1	2	2
<i>P. leucogenys</i> (White Cheeked Flying-Squirrel).	1	101	101
<i>P. magnificus</i> (Red-bellied Flying-Squirrel).	1	36	36
<i>P. oral</i> (Large Brown Flying-Squirrel).	1	3	3
<i>Sciuropterus</i> , whole genus	14	15	61
<i>S. fimbriatus</i> (Grey Flying-Squirrel) .	11	13.7	61
<i>S. layardi</i> (Layard's „ „) .	1	1	1
<i>S. volucella</i> (American „ „) .	2	30	37
= <i>volans</i> .			
<i>Spermophilus</i> , whole genus	24	17	132
<i>S. citillus</i> (European Souslik) ...	5	7.4	11
<i>S. grammurus</i> (Line-tailed „ „) ...	1	119	119
<i>S. mexicanus</i> (Mexican „ „) ...	3	47	132
<i>S. mongolicus</i> (Mongolian „ „) ...	4	10.7	22
<i>S. tridecemlineatus</i> (Thirteen-striped Souslik).	11	5.5	22
<i>Arctomys</i> , whole genus	23	64	164
<i>A. caudatus</i> (Long-tailed Marmot) .	1	15	15
<i>A. himalayanus</i> (Himalayan „ „) .	1	79	79
<i>A. hodgsoni</i> (Hodgson's „ „) .	2	73.5	74
<i>A. marmotta</i> (Alpine „ „) .	10	82	164
<i>A. monax</i> (Quebec „ „) .	9	57	116
<i>Cynomys ludovicianus</i> (Prairie „ „) .	48	30	98

I am unacquainted with any published observations as to the

longevity of Squirrels and other members of the Sciuridæ, and it was a surprise to find that a Squirrel had lived over fifteen years, a Flying-Squirrel over thirteen, a Souslik eleven, and a Marmot over thirteen. It first occurred to me that as these animals have not an individuality that is very obvious, mistakes with regard to individuals might have confused the records. Such an explanation, however, does not cover the facts; it would apply at least equally well to the Common Squirrel, the 77 examples of which showed no case of great longevity and a very low average, and it could not possibly account for the many cases of high longevity, where only two or three examples are recorded throughout the period of thirty-three years. We must take as established the striking fact that squirrel-like animals have a very high potential longevity in proportion to their size and in comparison with other vegetable-feeding forms, as the latter are on the whole relatively short-lived. The average duration and therefore the viability of the group appears to vary much; some species are almost uniformly unsuccessful, whilst others show a distribution of durations very close round the average. Taking the group as a whole, however, it has shown a relatively high viability just as it has a relatively high maximum longevity. It is particularly interesting to reflect that during the greater part of the period to which the figures relate, most of these squirrels were housed in outdoor cages freely open to the air, with no artificial heating, but with small nesting-boxes as retreats.

CASTORIDÆ.		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Castor fiber</i>	(European Beaver) ...	4	4·2	7
<i>C. canadensis</i>	(Canadian "	30	40·3	130

The great difference in viability between European and Canadian Beavers is remarkable. The average of the latter is relatively low on account of the large proportion that lived only a few months; if two or three months were survived these beavers usually lived some years. The number of European beavers within the period is small, and it may well be that it included no healthy, nearly adult individual.

MYOXIDÆ.		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Myoxus</i> ,	whole genus	23	14·6	35
<i>Myoxus dryas</i>	(Oak Dormouse)	6	12·5	30
<i>M. glis</i>	(Fat " ..)	3	14·3	34
<i>M. quercinus</i>	(Garden " ..)	14	15·5	35
<i>Muscardinus avellanarius</i>	(Common Dormouse).	17	3·5	13

The relative low viability of, or failure with, the common English Dormouse is remarkable. A high longevity is not to be anticipated for dormice, although I am unaware of any recorded

observations. Throughout the period in question, these animals were kept in a badly ventilated house, usually kept hot.

MURIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hydromys chrysogaster</i> (Golden-bellied Beaver-rat).	6	11	17
<i>Gerbillus</i> , whole genus	179	19	54
<i>G. ægyptius</i> (Lesser Egyptian Gerbillæ).	39	9	42
<i>G. campestris</i> (Field Gerbille)	2	32·5	36
<i>G. indicus</i> (Indian „	15	17	32
<i>G. longifrons</i> (Long-fronted Gerbille)	79	18·8	54
<i>G. pygargus</i> (White-rumped „)	2	17	28
<i>G. pyramidum</i> (Large Egyptian „)	14	14	24
<i>G. robustus</i> (Robust „)	2	12	16
<i>G. shawi</i> (Shaw's „)	26	18·8	35
<i>Psammomys obesus</i> (Fat Sand-Rat) .	1	17	17
<i>Georychus capensis</i> (Cape Mole-Rat) .	1	11	11
<i>Cricetus frumentarius</i> (Common Hamster).	12	17	27
<i>Cricetomys gambianus</i> (Gambian Pouched Rat).	8	20	33
<i>Mus</i> , whole genus	64	16	50
<i>M. arboricola</i> (Sydney Bush-Rat) ...	3	45	50
<i>M. bandicota</i> (Bandicoot Rat)	2	19·5	21
<i>M. barbarus</i> (Barbary Mouse)	20	19·5	33
<i>M. blanfordi</i> (Blanford's Rat)	3	5	8
<i>M. cervicolor</i> (Fawn-coloured Mouse)	2	13·5	18
<i>M. exulans</i> (Pacific Mouse)	9	3·6	7
<i>M. minutus</i> (Harvest Mouse).....	10	15·5	33
<i>M. rattus</i> (Black Rat)	13	17	41
<i>M. sylvaticus</i> (Long-tailed Field- Mouse).	2	4·5	7
<i>Isomys variegatus</i> (Varied Field-Rat)	7	52	81
<i>Acomys hunteri</i> (Hunter's Spiny Mouse).	11	38·4	53
<i>Arvicola</i> , whole genus	14	8	25
<i>A. agrestis</i> (Short-tailed Vole).....	7	8·3	25
<i>A. amphibius</i> (Water Vole)	5	9	16
<i>A. pratensis</i> (Bank Vole).....	2	7·5	14
<i>Myodes lemmus</i> (Norwegian Lemming)	5	5	19
<i>Fiber zibethicus</i> (Musquash)	7	14	75

The only published statement regarding the age of mice with which I am acquainted, is Metchnikoff's assignment of "five or six" years as their limit. It may be supposed that the larger forms have a higher potential longevity. The maximum duration in the record is nearly 7 years in the case of an Egyptian Field Rat. Comparatively few of the maxima approach this figure, and the relation between the maximum and average durations is fairly

close. As in proportion to their size these rodents have rather a high viability, it must be supposed that the conditions of detention in the interior of a house are not very unfavourable to them.

SPALACIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Rhizomys badius</i> (Bay Bamboo-Rat) .	5	17·4	41

DIPODIDÆ.

<i>Dipus ægyptius</i> (Egyptian Jerboa) ...	48	18·8	56
<i>D. hirtipes</i> (Hairy-footed Jerboa) ...	30	16	36
<i>Dipodillus simoni</i> (Simon's Dwarf Jerboa).	3	20	23
<i>D. campestris</i> (Dwarf Jerboa)	1	12	12
<i>Alactaga indica</i> (Indian Jerboa)	1	14	14
<i>A. decumana</i> (Persian Jerboa)	2	10·5	13

If Jerboas can be compared with rats and mice, the record of nearly five years for an Egyptian Jerboa is what might be expected, but the maxima for most of the species and the average durations show a low viability. The Jerboas have always been kept in a warmed house.

OCTODONTIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Octodon cumingi</i> (Cuming's Octodon) .	35	24	62
<i>Ctenodactylus gundi</i> (Gundi Rat) ...	2	5·5	7
<i>Myopotamus coypu</i> (Coypu)	39	30	121
<i>Capromys brachyurus</i> (Short-tailed Capromys).	3	11	15
<i>C. pilorides</i> (Fournier's Capromys) ...	5	36	116
<i>Aulacodus swindernianus</i> (Ground-Rat).	2	10·5	16

Some of the Octodontidæ are relatively large rodents and the record of 10 years for a Coypu is not surprising. The viability as shewn by the average duration is not high; in the case of the Coypus, which have always been provided with access to the open air, the average duration is lowered by high mortality amongst young born in the Gardens.

HYSTRICIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hystrix</i> , whole genus	34	89	245
<i>H. cristata</i> (Crested Porcupine) ...	26	70·9	245
<i>H. javanica</i> (Javan ") ...	6	123	181
<i>H. longicauda</i> (Sumatran ") ...	2	137	163
<i>Atherura africana</i> (African Brush-tailed Porcupine).	8	26·3	117
<i>A. fasciculata</i> (Indian Brush-tailed ").	2	29	50
<i>Erithizon dorsatus</i> (Canadian Porcupine).	3	18·3	32
<i>Sphingurus</i> , whole genus	18	23	107

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sphingurus insidiosus</i> (Guianan Tree Porcupine).	1	40	40
<i>S. mexicanus</i> (Mexican Tree Porcupine).	1	7	7
<i>S. prehensilis</i> (Brazilian Tree Porcupine).	9	15	47
<i>S. spinosus</i> (Spiny Tree Porcupine).	1	1	1
<i>S. villosus</i> (Hairy „ „).	6	40	107

The Porcupines are another set of animals regarding the longevity of which I am unaware of published information, and it is most interesting to find that they attain considerable ages, the record of over twenty years for a common porcupine being remarkable for a relatively small vegetable-feeding animal. The high average duration (over 7 years) of the whole genus *Hystrix* shows that these animals have a high viability. The contrast between the records of maximum and average durations for the genus *Hystrix* and those for other genera is extremely interesting. In the period in question, the species of *Hystrix* have been given free access to the open air and unheated shelters, whilst examples of other genera have been for the most part kept inside artificially heated houses.

Capt. Stanley Flower's record cases are not so high.

CHINCHILLIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Chinchilla lanigera</i> (Chinchilla)	38	30	84
<i>Lagotis cuvieri</i> (Cuvier's Lagotis) ...	1	18	18
<i>Lagostomus trichodactylus</i> (Viscacha) 30		32	81

DASYPROCTIDÆ.			
<i>Cælogenys paca</i> (Spotted Cavy)	35	22	92
<i>Dasyprocta</i> , whole genus	101	31	109
<i>D. acouchy</i> (Acouchy)	4	33·5	61
<i>D. aguti</i> (Golden Agouti)	20	27·7	101
<i>D. azarae</i> (Azara's „)	3	94	109
<i>D. cristata</i> (West Indian Agouti) 29		27	99
<i>D. isthmica</i> (Central American „) 15		31	97
<i>D. mexicana</i> (Mexican „) 2		11·5	14
<i>D. prymnolopha</i> (Hairy-rumped „) 20		32	108
<i>D. punctata</i> (Punctated „) 8		28	84

CAVIDÆ.			
<i>Dolichotis patachonica</i> (Patagonian Cavy). 18		30	93
<i>Cavia flavidens</i> (Yellow-toothed Cavy). 1		10	10
<i>C. spixi</i> (Spix's Cavy)	4	28	48
<i>Cerodon rupestris</i> (Rock-Cavy)	4	14	40
<i>Hydrochaerus capybara</i> (Capybara) ... 18		33	114

The Agoutis and Cavies are another instance of small Rodents which come from various kinds of climates, but which have been treated as outdoor animals and show a relatively high maximum and average longevity.

LEPORIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Lepus</i> , whole genus	23	13	71
<i>L. americanus</i> (American Hare)	3	2	2
<i>L. brasiliensis</i> (Brazilian ")	3	6.3	10
<i>L. europæus</i> (Common ")	10	20	71
<i>L. nigricollis</i> (Black-necked ")	1	1	1
<i>L. sylvaticus</i> (Wood ")	4	13	41
<i>L. variabilis</i> (Varying ")	2	6.5	12

Metchnikoff has set down ten years as a great age for a rabbit; and hence the record duration of nearly seven years for the common hare is not high. The very low average duration shows a poor viability. As there would seem to be no special difficulty in providing Leporidæ with conditions suitable to them, there is probably some special reason for their low viability in captivity. It is a remarkable circumstance that many of the most common wild animals of Europe are difficult to keep in captivity. I think it is quite possible that the fear of man which such animals have acquired in their wild state, almost as a necessary condition of their existence, by continuing to act after captivity, shortens the life, often by accident, often by reaction of the mental state on the general health. Animals from remoter parts of the world have not an acquired intolerance of man to lose.

Summary of Rodentia.

It is unlikely that animals in captivity reach the potential longevities of their races, and it is a new and somewhat surprising fact that Rodents live so long as these records show. There is only a rough correspondence between maximum durations and size, the figures amongst Rodents ranging from 20 years in the Porcupine, 15 in some Squirrels, 13 in Marmots, 11 in Sousliks, 9 in Agoutis and Capybaras, down to 3 in Dormice. Metchnikoff has shown (*tom. cit.*) that on the whole there is an inverse proportion between the relative capacity of the large intestines and the duration of life, animals with a capacious hind-gut usually being shorter-lived in proportion to their size than those in which the hind-gut is reduced. Rodents certainly present a marked exception to his general rule, for in their case the hind-gut and cæcum are relatively very long and very capacious. The relatively high viability of Rodents is another remarkable fact, and is most striking in comparison with Insectivora. Their high specific longevities and viabilities may be associated, I think, with the

fact that they are a successful group, with remarkable power of adaptation to different environments.

The most important practical result is the very striking series of contrasts between the average and maximum durations of those animals which have had free access to fresh air and of those which have been deprived of such access by detention in heated houses,—a contrast that seems independent of the natural habitat of the animals in question.

HYRACES.			
	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hyrax capensis</i> (Cape Hyrax)	10	15.2	50
<i>H. dorsalis</i> (Dorsal „)	2	18.5	36

I can find no other records which would throw light on the potential longevity of these animals, the zoological position of which is very doubtful. It is impossible to tell their ages if they are adult on arrival, and therefore the maximum duration of just over four years gives no reliable indication of the potential longevity. As these animals have a most complex and capacious hind-gut, and as they are vegetable-feeders, a high viability or great longevity is not to be expected, according to Metchnikoff's views. In the period covered by these figures, the Hyraces were almost invariably given access to open air.

Capt. Stanley Flower's figures are lower.

PROBOSCIDEA.			
	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Elephas africanus</i> (African Elephant) 1		101	101
<i>E. indicus</i> (Indian „) 3		196	290

Metchnikoff has already pointed out that there is no exact basis for the popular ascription of very high potential longevity to these animals. It used to be thought that they could live for several centuries. Flourens, using his formula based on the age at which the epiphyses unite with the long bones, set down 150 years as the limit of their age. Indian natives ascribe a limit of from 80 to 150 years. On the other hand, the official list of the Indian Government, cited by Brehm, shows that of 138 elephants only one lived for more than 20 years after it had been purchased. Twenty to twenty-five years' duration in a menagerie is regarded as good. The record in this list of about 24 years has been far surpassed by a female Indian Elephant, brought as a young animal by the Prince of Wales from India in 1876, and still alive and apparently in quite good condition in our Gardens; although its age is certainly over 34 years. I agree with the general conclusion of Metchnikoff, that elephants, in proportion to their size, have neither a high potential longevity nor a good viability, not much more than a hundred years being the probable age limit, and twenty to thirty years a fair average duration.

UNGULATA.

1. Perissodactyla.

RHINOCEROTIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Rhinoceros</i> , whole genus	10	110	342
<i>R. bicornis</i> (Two-horned African Rhinoceros).	1	271	271
<i>R. lasiotis</i> (Hairy-eared Rhinoceros)	3	132	342
<i>R. sondaicus</i> (Javan ")	1	130	130
<i>R. sumatrensis</i> (Sumatran ")	4	7.5	17
<i>R. unicornis</i> (Indian ")	1	281	281

Rhinoceroses, like Elephants, are large vegetable-feeding mammals, with in proportion to their size a relatively low potential longevity and viability. The maximum duration in this record, nearly 29 years for a so-called "Hairy-eared" example, has since been surpassed by an Indian Rhinoceros which died after a duration of 40 years in our Gardens, and probably therefore at an age of at least 42 years. The number of examples in the record is not sufficient to make averages useful, but these and information I have received elsewhere make it clear that the viability is not good, and probably lower in the case of the African species.

TAPIRIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tapirus americanus</i> (American Tapir) .	13	43	188
<i>T. indicus</i> (Malay Tapir)	2	4	5

The record of over 15 years for an American Tapir no doubt is under the potential longevity of these animals, but I can find no reliable information from other sources. The very low figures for the Malay Tapir refer only to two individuals, and there is no sufficient reason to suppose that the Asiatic species is less viable than the American. It must, however, be inferred that Tapirs in regard to their size are short-lived creatures with low viability.

EQUIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Equus</i> , whole genus	21	116	346
<i>E. hemionus</i> (Kiang)	1	220	220
<i>E. hemippus</i> (Asiatic Wild Ass).....	3	82	169
(= <i>hemionus indicus</i>).			
<i>E. onager</i> (Onager)	2	198	219
<i>E. somalicus</i> (Somali Wild Ass)	1	16	16
<i>E. teneipus</i> (African Wild Ass)	3	175	232
<i>E. quagga</i> (Quagga)	1	346	346
<i>E. burchelli</i> (Burchell's Zebra)	7	98	268
<i>E. grevyi</i> (Grevy's Zebra)	2	6	10
<i>E. zebra</i> (Mountain Zebra)	1	46.5	62

It is well-known that the usual duration of life in horses is from 15 to 30 years, and somewhere about 50 is probably the potential

longevity of the group. The record of a 29 years' duration in the case of a Quagga is therefore quite good, and if it be remembered that the figures include a number of newly imported and young animals, the average duration and viability are both good. On the other hand, they are in accordance with Metchnikoff's views as to the relatively low viability and longevity of animals with capacious hind-guts, for they are not high in proportion to the size of the animals and their ready submission to captivity.

Summary of Perissodactyla.

These animals, in consideration of the ease of procuring suitable food, do not afford evidence of high potential longevity or of great viability in proportion to their size.

2. Artiodactyla.

BOVINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Bos indicus</i> (Zebu)	20	64·5	230
<i>Bos taurus</i> (English Domestic White Ox).	13	32	145
<i>Bison americanus</i> (American Bison)...	9	70	129
<i>B. bonasus</i> (European „)...	1	14	14
<i>Poephagus grunniens</i> (Yak)	5	56	107
<i>Bibos frontalis</i> (Gayal)	5	138	188
<i>B. gaurus</i> (Gaur)	1	30	30
<i>Bubalus æquinoctialis</i> (E. African Buffalo).	2	57	90
<i>B. buffelus</i> (Indian Buffalo)	1	20	20
<i>B. caffer</i> (Cape „)	2	118·5	175
<i>Anoa depressicornis</i> (Anoa)	2	63·5	126
All Bovines	61	63·3	230

According to Metchnikoff, the duration of life in cattle is very short considering their size. The potential longevity is probably not much over 30 years; at 5 years old they begin to show signs of age and at from 16 to 18 they lose reproductive powers. The records quoted above are wholly in accordance with this estimate; the maximum duration of nearly 20 years is good, and the average duration is what might be expected reasonably. Throughout the period in question, the cattle were kept in unwarmed shelters, with access to the open air.

Capt. Flower has no high records.

BUBALINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Bubalis boselaphus</i> (Bubaline Antelope). 2	2	115	162
<i>B. caama</i> (Hartebeest)..... 3	3	65	85
<i>B. tora</i> (Tora Antelope)	3	55	86
<i>Damaliscus albifrons</i> (Bless-bok)	5	120	133
<i>D. pygargus</i> (Bonte-bok)	2	28	55
<i>Connochaetes gnu</i> (White-tailed Gnu). 4	4	102·5	164
All Bubalines	19	83	162

The records of Bubaline Antelopes correspond closely with those of cattle. From their smaller size so high a potential longevity is not to be expected; whereas, on the other hand, the higher average duration is probably due to the absence of young calves, the mortality amongst which lowered the record of cattle.

CEPHALOPHINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cephalophus</i> , whole genus	49	23	109
<i>C. coronatus</i> (Crowned Duiker).....	4	11	20
<i>C. dorsalis</i> (Bay ").....	7	26	75
<i>C. grimmii</i> (Common ").....	13	22·7	107
<i>C. maxwelli</i> (Maxwell's ").....	10	34	109
<i>C. monticola</i> (Blue ")	9	14·9	43
<i>C. nigrifrons</i> (Black-fronted Duiker)	1	3	3
<i>C. rufilatus</i> (Red-flanked ")	4	27	38
<i>C. sylvicultrix</i> (Yellow-backed ")	1	3	3
<i>Tetraceros quadricornis</i> (Four-horned Antelope).	19	28	66

The maximum and average durations of the Cephalophine Antelopes are rather lower in proportion to their size than those of the Bubaline Antelopes. There has been omitted from the tables, however, a considerable number of examples that lived less than a month in the Gardens.

NEOTRAGINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Oreotragus saltator</i> (Klipspringer)	1	46	46
<i>Raphicerus melanotis</i> (Grys-bok).....	2	6·5	10
<i>R. tragulus</i> (Stein-bok)	2	3	4
<i>Ourebia nigricaudata</i> (Gambian Ourebi).	3	40	105

The number of individuals is too small to make inferences useful.

CERVICAPRINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cobus ellipsiprymnus</i> (Common Water-buck).	3	39·3	47
<i>C. unctuosus</i> (Sing-sing Water-buck).	4	100	183
<i>Cervicapra isabellina</i> (Isabelline Antelope).	2	19	36
<i>C. bohor</i> (Bohor Antelope)	2	43	83

ANTILOPINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Gazella</i> , whole genus	118	24·4	112
<i>G. arabica</i> (Arabian Gazelle).....	20	18	71
<i>G. bennetti</i> (Indian ").....	11	10·8	57
<i>G. cuvieri</i> (Cuvier's ").....	1	3	3
<i>G. dorcas</i> (Egyptian ").....	27	22·7	94
<i>G. euchores</i> (Spring-bok)	9	20	65

ANTILOPINÆ (cont.).		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Gazella loderi</i>	(Loder's Gazelle)	1	55	55
<i>G. marica</i>	(Marica ")	2	41	71
<i>G. mohr</i>	(Mohr's ")	1	58	58
<i>G. muscatensis</i>	(Muscat ")	8	18	45
<i>G. rufifrons</i>	(Korin ")	2	21	38
<i>G. sømmerringi</i>	(Sømmerring's Gazelle)	8	31	69
<i>G. spekii</i>	(Speke's Gazelle)	2	47·5	73
<i>G. subgutturosa</i>	(Persian Gazelle)	26	33·5	112
<i>Antelope cervicapra</i>	(Indian Antelope)	7	36	100

The Gazelles in proportion to their size have a good maximum and average duration.

HIPPOTRAGINÆ.

<i>Hippotragus</i>	<i>equinus</i>	(Equine Antelope)	1	123	123
<i>H. niger</i>	(Sable Antelope)		2	68	89

ORYGINÆ.

<i>Oryx</i>	whole genus		15	83	216
<i>O. beatrix</i>	(Beatrix Antelope)		6	24	90
<i>O. beisa</i>	(Beisa ")		4	129	177
<i>O. leucoryx</i>	(Leucoryx ")		5	127	216
<i>Addax</i>	<i>naso-maculatus</i> (Addax Antelope)		2	178	219

With exception of the Beatrix Antelope the members of this fair-sized and handsome group display a remarkable longevity, 18 years being the record, and a high average viability.

TRAGELAPHINÆ.

		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Oreas canna</i>	(Eland)	16	71	118
<i>Strepsiceros kudu</i>	(Kudu)	6	35	94
<i>S. imberbis</i>	(Lesser Kudu)	2	44·5	80
<i>Tragelaphus gratus</i>	(Pleasant Antelope)	2	42·5	78
<i>T. scriptus</i>	(Harnessed Antelope)	12	36	72
<i>T. sylvaticus</i>	(Bosch-bok)	4	49	82
<i>Boselaphus tragocamelus</i>	(Nylghaie) ...	9	71·4	146

The large Tragelaphine Antelopes have a proportionally high maximum duration and their average duration shows that even including the Kudu, which has been supposed to be specially delicate in London, they have a good viability.

RUPICAPRINÆ.

<i>Rupicapra tragus</i>	(Alpine Chamois) ...	1	24	24
<i>Nemorhædus goral</i>	(Goral Antelope) ...	1	212	212

The most striking feature about these records of Antelopes is that in proportion to their size, they appear to have better lives than the cattle. Within the group there is a fairly close correspondence between size and duration, but a few species such as the Beatrix and the Chamois are specially delicate. The conditions under which these animals have been kept vary as to the provision of artificial heat, most of the Gazelles having been least well provided with it, but in nearly every case there has been access to the open air.

Capt. Flower's records of maximum duration are specially interesting, as it is to be expected that the climate of Egypt would be specially favourable to Antelopes. His highest figures, however, do not differ much from ours; 8 years for a *Cobus defassi*, still alive, over 11 years for a Dorcas Gazelle, 10 years for a Sæmmerring's Gazelle and for a Sabre-horned Oryx.

CAPRINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Capra</i> , whole genus	50	50	166
<i>C. aegagrus</i> (Grecian Ibex)	5	59	157
<i>C. caucasica</i> (Caucasian Ibex)	2	54·5	78
<i>C. hircus</i> (Angora Goat)	18	53·5	166
<i>C. hispanica</i> (Spanish Ibex)	1	32	32
<i>C. ibex</i> (Alpine „)	2	103	103
<i>C. megaceros</i> (Markhoor)	15	55	133
<i>C. nubiana</i> (Nubian Ibex)	6	24	101
<i>C. sinaitica</i> (Sinaitic „)	1	45	45
<i>Hemitragus jemlaicus</i> (Thar)	10	51	143
<i>Ovis</i> , whole genus	68	46	231
<i>O. blanfordi</i> (Blanford's Sheep)	1	46	46
<i>O. burrhel</i> (Burrhel Wild Sheep)	21	46·7	193
<i>O. cycloceros</i> (Punjab „ „)	6	51	137
<i>O. hodgsoni</i> (Great Tibetan Sheep) ...	2	20	31
<i>O. musimon</i> (Mouflon)	15	50	231
<i>O. tragelaphus</i> (Barbary Wild Sheep) .	21	43	134
<i>O. vignei</i> (Urial)	2	15	28

Sheep and goats are supposed to have a shorter life than cattle. Metchnikoff, quoting Grindon, assigns 14 years as an extreme age for domestic sheep, 12 an old age, and 8 to 10 as the time when senile changes are expected. These records show that wild species of sheep and goats may attain great ages, a goat having lived about 14 years and a Mouflon over 19 years in the Gardens. The average duration is lowered by the number of lambs the life of which was not good, and if this allowance be made, it is clear that the sheep and goats have a fairly good viability. They are of course kept with free access to the open air.

Capt. Flower gives no higher records.

ANTILOCAPRIDÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Antilocapra americana</i> (Pronghorn)	6	9	30

Pronghorn Antelopes are notoriously delicate in captivity, not only in London, but in other zoological collections. The records afford no information as to the specific longevity, and only confirm knowledge as to the low viability of these animals.

GIRAFFIDÆ.

<i>Giraffa</i> , whole genus	10	101·9	229
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It is to be expected that Giraffes, in correspondence with their large size, should have a relatively great specific longevity compared with other ruminants. The record, a duration of over 19 years, is just surpassed by that of a Zebu, and whilst it is fairly high, is certainly not high in proportion to the great size of the animal. The average duration shows a fairly good viability. Giraffes have always been given artificial heat in cold weather, and for the most part have been allowed access to the open air only in summer.

Capt. Flower records a Giraffe still alive after 8 years' duration.

CERVIDÆ.

MOSCHINÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Moschus moschiferus</i> (Musk-deer)	4	26	65

Musk-deer have shown a low viability. There is some difficulty as to their food in captivity, as their natural diet of twigs and buds is difficult to supply; they are animals capable of surviving extreme exposure to cold, and in captivity have probably been subjected to too much artificial warmth.

CERVINÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cervulus</i> , whole genus	14	71	126
<i>C. crinifrons</i> (Hairy-fronted Muntjac)	1	73	73
<i>C. lacrymans</i> (Crying Muntjac)	1	126	126
<i>C. muntjac</i> (Indian ")	7	39	96
<i>C. reevesi</i> (Reeves's ")	5	105	121
<i>Elaphodus michianus</i> (Michie's Tufted Deer)	9	16	46
<i>Cervus</i> , whole genus	173	68·8	243

Red-deer group.

<i>Cervus elaphus</i> (Red Deer)	17	69	191
<i>C. kashmirianus</i> (Kashmir Deer)	1	148	148
<i>C. maral</i> (Persian ")	3	98	172
<i>C. luehdorfi</i> (Lühdorf's ")	2	52·5	79
<i>C. canadensis</i> (Wapiti ")	10	156·9	243

Sika group.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cervus sika</i> (Japanese Deer)	39	52	160
<i>C. mantchuricus</i> (Mantchurian Deer) .	4	116	170
<i>C. taevanus</i> (Formosan ") .	4	95	149
Axis group.			
<i>C. axis</i> (Axis Deer).....	27	56	158
Sambar group.			
<i>C. aristotelis</i> (= <i>unicolor</i>) (Sambar Deer). 17	48	142	
<i>C. hippelaphus</i> (Rusa Deer)	3	26	33
<i>C. moluccensis</i> (Molucca ")	12	69	219
<i>C. philippinus</i> (Philippine ")	3	55	56
<i>C. kuhli</i> (Kuhl's ")	2	37	66
<i>C. alfredi</i> (Prince Alfred's ")	5	51	93
<i>C. porcinus</i> (Hog ")	16	60.5	119
Swamp Deer group.			
<i>C. duvaucelli</i> (Barasingha Deer) ...	1	220	220
<i>C. schomburgki</i> (Schomburgk's ") ...	1	157	157
<i>C. eldi</i> (Panolia ") ...	3	58	91
<i>C. davidianus</i> (Père David's Deer) ...	3	49	92
<i>Dama mesopotamica</i> (Persian Fallow Deer).	8	60	124
<i>D. vulgaris</i> (Common Fallow Deer) ...	8	42	120
<i>Alces machlis</i> (Moose).....	6	32.7	62
<i>Hydropotes inermis</i> (Chinese Water-Deer).	3	70	129
<i>Capreolus caprea</i> (Common Roe-deer).	9	24	52
<i>C. pygargus</i> (White-rumped Roe-deer).	1	6	6
<i>Cariacus</i> , whole genus	83	31	146
<i>C. campestris</i> (Pampas Deer)	6	12	24
<i>C. gymnotis</i> (Naked-eared Deer).....	5	14.5	40
<i>C. leucurus</i> (White-tailed ").....	1	69	69
<i>C. macrotis</i> (Mule ").....	24	49	146
<i>C. mexicanus</i> (Mexican ").....	18	31	91
<i>C. nemorivagus</i> (Wood Brocket).....	7	17	32
<i>C. rufus</i> (Red ").....	6	13	35
<i>C. virginianus</i> (Virginian Deer).....	16	27	81
<i>Furcifer chilensis</i> (Gemul ").....	1	131	131
<i>Pudua humilis</i> (Pudu ").....	4	31	108
<i>Rangifer tarandus</i> (Reindeer)	11	41	116

Stags are supposed to be long-lived animals, and Flourens has set down 30 to 40 years as the duration of their lives. The longest record on this list, over 20 years in the case of a Wapiti, does not lead one to infer that in proportion to their size the

potential longevity of Cervidæ differs much from that of other ruminants. Within the group, there is the usual rough correspondence between duration and size, the larger animals reaching greater ages and being hardier than the smaller animals; the records of average duration are lower, in some cases (*e. g.* Sika, Axis and Red Deer), reduced by breeding, the mortality amongst the young being heavy. Some kinds of Deer have a specially low viability in captivity, as for instance the Moose, most probably on account of the difficulty of supplying it with natural food, whilst all Deer of the genus *Cariacus* except the Mule Deer appear to be naturally delicate. The vast majority of the deer have been kept under similar conditions, with unwarmed shelters and free access to the open air.

Capt. Flower's highest record is that of an Axis-deer, still alive after over 9 years' duration.

TRAGULIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tragulus</i> , whole genus	28	11.4	50
<i>T. javanicus</i> (Javan Chevrotain)	10	9.9	43
<i>T. meminna</i> (Indian ")	9	12	33
<i>T. stanleyanus</i> (Stanley's ")	9	12	50
<i>Hyomoschus aquaticus</i> (Water Chevrotain)	11	4	11

Nothing is known as to the potential longevity of Chevrotains, and the record of over four years would appear to be considerably lower than what might be anticipated for these animals. The viability in captivity is very low, and the records of average duration would be much lower if a considerable number of examples that lived for less than a month had been included. These animals have always been assumed to require special protection from cold and have been kept in warmed houses without access to the open air.

CAMELIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Lama</i> , whole genus	14	69	187
<i>L. huanacos</i> (Huanaco)	6	72	187
<i>L. pacos</i> (Alpaca)	2	9	14
<i>L. peruana</i> (Llama)	6	95	156
<i>Camelus dromedarius</i> (Dromedary)	6	44	145
<i>C. bactrianus</i> (Bactrian Camel)	5	110	204

Flourens has set down the life of a Camel as reaching to 40 years, but the longest record amongst the Camelidæ is only 17 years. A Llama that died at the Gardens recently, after a duration of 15 years, showed plain evidence of senile degeneration. The figures of average and maximum duration show that the Camelidæ, notwithstanding their size, and the absence of difficulty in providing appropriate food and accommodation, are not long-lived animals.

HIPPOPOTAMIDÆ.		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hippopotamus amphibius</i>	(Hippo- potamus).	3	290	335

The maximum duration of nearly 28 years has been surpassed by a female Hippopotamus, born in the Gardens and which recently died at the age of 39 years. The viability of these animals is good, if they are sufficiently protected from cold in winter, but it is to be noticed that if the maximum ages attained give any indication of the potential longevity, the Hippopotamus, in proportion to its size, cannot be regarded as a long-lived animal.

PHACOCHERIDÆ.		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Phacochoerus africanus</i>	(Ælian's Warthog)	1	24	24
<i>P. æthiopicus</i>	(Æthiopian Warthog).....	6	55	131

SUIDÆ.				
<i>Sus</i> , whole genus	25	55	234	
<i>Sus andamanensis</i> (Andaman Swine) ...	2	134	147	
<i>S. cristatus</i> (Indian Wild Swine)	2	54.5	89	
<i>S. leucomystax</i> (White-whiskered Swine)	5	65.8	158	
<i>S. papuensis</i> (Papuan Pig)	1	74	74	
<i>S. scrofa</i> (Wild Swine)	15	40	234	
<i>Porcula salvania</i> (Pigmy Hog)	5	48	90	
<i>Babirussa alfurus</i> (Babirussa)	6	41	126	
<i>Potamochoerus africanus</i> (Southern River- Hog)	5	86	176	
<i>P. pericillatus</i> (Red River-Hog)	6	4	11	
<i>Dicotyles labiatus</i> (White-lipped Peccary)	5	71	112	
<i>D. tajaçu</i> (Collared Peccary)	20	22.9	162	

The maximum duration of nearly 20 years for one of the Wild Swine corresponds with the limits that various authors have assigned to such animals. The viability is not good, and the average would be much lower if a number of animals whose duration was less than a month had not been omitted. Capt. Flower's highest records are that of a Wild Swine still alive after 12 years' duration, and a Babirussa alive after 9 years' duration.

Summary of Artiodactyla.

The Artiodactyla contain animals of so many different kinds, that we cannot expect to find a close correspondence between size and longevity throughout the whole group, although on the whole such a correspondence exists throughout the sub-groups. The group as a whole is not notable for longevity in proportion to size, and as the majority are vegetable-feeders with capacious hind-gut and great tendency to intestinal putrefaction, the general condition is in agreement with Metchnikoff's theory. Antelopes, sheep and goats, and deer appear in proportion to their size to have better viability than cattle, giraffes and camels, whilst on the whole the non-ruminants are hardier, in proportion to their size, than the ruminants.

CETACEA AND SIRENIA.

Very few examples are contained in the records, and the duration of these was only sufficient to show the complete unsuitability of the conditions and certainly afforded no indication as to the general viability and longevity of these animals. There is of course abundant evidence from other sources as to the high potential longevity of Cetaceans, but I know of no definite evidence with regard to Sirenians, which as vegetable-feeders with complicated intestines might be supposed to have short lives in proportion to their bulk.

EDENTATA.

BRADYPODIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Bradypus tridactylus</i> (Three-toed Sloth).	8	under 1	1
<i>Cholopus didactylus</i> (Two-toed Sloth) ...	2	7	13
<i>C. hoffmanni</i> (Hoffmann's Sloth)	14	29	133

I am ignorant as to any recorded information regarding the potential longevity and viability of Sloths. Lydekker, in the Royal Natural History, remarks on their power of recovery from injury and capacity for enduring long periods of starvation, correlating these qualities with general low organization, and comparing the animals with reptiles. Certainly, however, it cannot be assumed that creatures of low organization have a relatively high potential longevity. As Sloths are rather small, vegetable-feeding animals, with fairly bulky hind-guts, on Metchnikoff's theory, their duration of life and viability ought to be low. The maximum record of over 11 years for a Hoffmann's Sloth is certainly high, but the average duration of Sloths is extremely bad. The failure has been complete in the case of the Three-toed Sloths, very great with the Two-toed, whilst there has been a partial but very irregular success in the case of Hoffmann's Sloth. Sloths are nocturnal inhabitants of tropical forests, and in captivity they have been assigned confined quarters in warmed houses, without access to the open air. Their quiescence by day probably has led to the need of air and exercise at night being overlooked.

DASYPODIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tatusia hybrida</i> (Mulito Armadillo) ...	6	8.5	40
<i>T. peba</i> (Peba Armadillo)	16	17	45
<i>T. kappleri</i> (Kappler's Armadillo)	2	53	54
<i>Dasytus minutus</i> (Little Armadillo) ...	6	19	23
<i>D. sexcinctus</i> (Six-banded Armadillo) ...	6	9.3	19
<i>D. villosus</i> (Hairy Armadillo)	31	33	157
<i>Xenurus unicinctus</i> (Broad-banded Armadillo).	2	6	11
<i>Tolypeutes tricinctus</i> (Brazilian Three- banded Armadillo).	1	8	8

Regarding the potential longevity of Armadillos, I am unaware of any recorded information. They live on carrion, insects and vegetables, and the hind-gut is of very moderate relative capacity. The record of 13 years for a Hairy Armadillo seems good, but the average duration is very much less than that. Throughout the period in question most of the Armadillos were kept in the interior of a badly ventilated and very warm room.

Capt. Flower records a duration of over 8 years for a Hairy Armadillo.

MYRMECOPHAGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Myrmecophaga jubata</i> (Great Ant-eater).	10	46	172
<i>Tamandua tetradactyla</i> (Tamandua Ant-eater).	12	10·8	60

The records of $14\frac{1}{2}$ years for a Great Ant-eater and 5 years for a *Tamandua* Ant-eater are very much in excess of the average duration of these animals. They have always been carefully protected from cold, and not allowed access to the open air. It is plain that they are creatures of low viability compared with their potential longevity, but that they have been subjected to very unsuitable conditions.

MANIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Manisticuspis</i> (White-bellied Pangolin).	1	1	1
<i>M. (Pholidotis) gigantea</i> (Giant Pangolin).	1	1	1

The records only testify to the failure to keep these animals in captivity.

ORYCTEROPIDÆ.			
<i>Orycteropus capensis</i> (Cape Ant-bear) ...	4	52	117
<i>O. æthiopicus</i> (Æthiopian Ant-bear) ...	1	17	17

The record of over 9 years for a Cape Ant-bear gives an indication that these animals are able to live to a considerable age. The difference between the maximum and average durations shows the low viability of these animals under the conditions of their captivity. In the period in question they have been kept in heated houses without access to open air.

Summary of Edentata.

The most notable feature in the records is their great variation. The maximum durations are sufficient to deduce from them that these animals have a fairly high potential longevity which varies roughly with their size, and that their viability is low under the conditions in which they have been kept.

MARSUPIALIA.

MACROPODIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Macropus</i> , whole genus	200	30·2	166
<i>M. agilis</i> (Agile Wallaby)	5	21	43
<i>M. bennetti</i> (Bennett's ")	35	30	112
<i>M. billardieri</i> (Red-bellied ")	7	12	38
<i>M. brachiuus</i> (Short-tailed Wallaby) ...	15	16	41
<i>M. derbianus</i> (Derbian ") ...	19	38	118
<i>M. dorsalis</i> (Black-striped ") ...	8	23	62
<i>M. giganteus</i> (Great Kangaroo)	30	31	137
<i>M. melanops</i> (Black-faced Kangaroo) ...	13	37	164
<i>M. parryi</i> (Parry's Wallaby).....	1	5	5
<i>M. robustus</i> (Great Wallaroo)	15	25	83
<i>M. ruficollis</i> (Rufous-necked Wallaroo) .	6	14	28
<i>M. rufus</i> (Red Kangaroo).....	30	43·8	166
<i>M. thetidis</i> (Thigh-striped Wallaby).....	4	26	54
<i>M. ualabatus</i> (Black-tailed ").....	12	30	76
<i>Petrogale</i> , whole genus	44	30	89
<i>P. brachyotis</i> (Short-eared Kangaroo)...	1	3	3
<i>P. penicillata</i> (Brush-tailed ") ...	15	31	89
<i>P. xanthopus</i> (Yellow-footed Rock Kangaroo).	28	31	79
<i>Onychogale frenata</i> (Bridled Wallaby)...	12	5·3	10
<i>O. unguifera</i> (Nail-tailed ") ...	6	1	2
<i>Dorcopsis luctuosus</i> (Mourning Kangaroo)	1	7	7
<i>D. mülleri</i> (Müller's Kangaroo)	1	15	15
<i>Dendrolagus inustus</i> (Brown Tree Kan- garoo).	1	19	35
<i>D. bennetti</i> (Bennett's Tree Kangaroo) .	4	18	43
<i>Aepyprymnus rufescens</i> (Rufous Rat- Kangaroo).	19	35	70
<i>Bettongia</i> , whole genus	24	40	94
<i>B. cuniculus</i> (Tasmanian Rat-Kangaroo).	3	29	59
<i>B. gaimardi</i> (Gaimard's " ") .	15	30	79
<i>B. lesueurii</i> (Lesueur's " ") .	3	78	94
<i>B. penicillata</i> (Ogilby's " ") .	3	52	87
<i>Potorous tridactylus</i> (Common Rat-Kan- garoo).	5	13	16
PHALANGERIDÆ.			
<i>Dromicia nana</i> (Dormouse Phalanger) .	4	26·5	64
<i>Petaurus</i> , whole genus	48	40	130
<i>P. australis</i> (Yellow-bellied Phalanger).	2	92·5	121
<i>P. breviceps</i> (Short-headed ") .	32	33	130
<i>P. sciureus</i> (Squirrel-like ") .	14	48	123
<i>Pseudochirus peregrinus</i> (Ring-tailed Phalanger).	1	4	4
<i>Trichosurus</i> , whole genus	71	22	142
<i>T. caninus</i> (Short-eared Phalanger).....	1	89	89
<i>T. fuliginosus</i> (Sooty ").....	7	27	76
<i>T. orientalis</i> (Oriental ").....	1	3	3
<i>T. vulpecula</i> (Vulpine ").....	62	21	142
<i>Phascolarctos cinereus</i> (Koala)	3	5·6	8

It is impossible to separate, by any important characters, the Kangaroos, Wallabies, Rock Kangaroos, Rat-Kangaroos, and Phalangers. They form a series roughly corresponding with the ruminants amongst higher mammals, and have similar habits and food. The alimentary tract, although much simpler in structure than that of ruminants, possesses a capacious hind-gut and cæcum, and they are therefore animals that might be expected to have low potential longevity and poor viability. The maximum duration in the group, nearly 14 years in the case of a kangaroo, is more or less what might be expected, and on the whole there is a rough correspondence between size and longevity. The average duration is low compared with the maximum duration, and it is a fair inference that the viability is not good. Amongst the Phalangers, however, there are remarkable exceptions, the maximum duration and the average duration, in a number of cases, being unusually high in proportion to size. In reflecting upon this I was disposed at first to distrust the records; in animals so little individualized it might well be that mistakes had been made as to individuals, and hence that wrong durations had been assigned in the records. Although this may well have happened in some of the cases, it is not a sufficient explanation. A period of 33 years is covered by the records, and even where the number of individuals was largest, the number of individuals alive at any one time was probably not more than 3 or 4 at most, and the chance of confusion was therefore not great; there are moreover cases of remarkable duration where the number of individuals was so small as to make confusion practically or absolutely impossible,—of two Yellow-bellied Phalangers, for instance, one lived over 10 years, and one Short-eared Phalanger lived over 7 years. It is clear that these animals have a high viability. In the period covered by the record some of them were kept in fairly roomy cages, but in an artificially heated house without access to the open air. Others were kept in small outdoor cages with no artificial heat. Unfortunately I cannot now trace which individuals lived in these very different kinds of quarters. Since the period in question several species have thriven in a shed open to the outer air, without artificial heat, but with protection from wind. Capt. Flower records a Great Grey Kangaroo, a Black-faced Kangaroo, and a Wallaroo, each alive after 10 years' duration.

PHASCOLOMYIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Phascolomys</i> , whole genus.....	13	74	212
<i>P. latifrons</i> (Hairy-nosed Wombat).....	4	88	212
<i>P. mitchelli</i> (Common „).....	9	68	189

A record of nearly 18 years for a Wombat seems to show that these animals have a high potential longevity in proportion to their size, whilst their viability, as shewn by the average duration, is good. Throughout the period, they were kept in an unheated shelter with free access to the open air.

PERAMELIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Peragale lagotis</i> (Rabbit-eared Bandicoot).	8	19·8	32
<i>Perameles obesula</i> (Short-nosed „).	3	8	17

These little omnivorous and carnivorous marsupials show low maximum and average durations. They have a capacious hind-gut and cæcum in proportion to their size. They have been kept in small cages in a heated house, without access to fresh air, and have not done well.

DASYURIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Thylacinus cynocephalus</i> (Tasmanian Wolf).	7	43	103
<i>Sarcophilus ursinus</i> (Tasmanian Devil) .	7	52·5	61
<i>Dasyurus</i> , whole genus	44	33	82
<i>D. maculatus</i> (Spotted-tail Dasyure) . . .	5	37	75
<i>D. viverrinus</i> (Maugé's „).....	39	28·5	82

Compared with Carnivora of similar sizes, the maximum duration of these carnivorous marsupials is not so high, suggesting possibly a low potential longevity. On the other hand, the average duration is rather better in proportion, which may be evidence of a greater viability. The conditions under which they have been kept are similar to those of true Carnivora: larger forms like the Thylacine have been given unheated shelters with access to the open air; the smaller forms, for the most part, have been confined in artificially warmed houses.

DIDELPHYIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Didelphys</i> , whole genus	92	10·8	85
<i>D. azarae</i> (Azara's Opossum)	20	8	28
<i>D. cancrivorus</i> (Crab-eating Opossum).	31	13	85
<i>D. cinereus</i> (Cinereous „).	1	5	5
<i>D. crassicaudata</i> (Thick-tailed „).	5	16	28
<i>D. lanigera</i> (Woolly „).	6	19	53
<i>D. murina</i> (Murine „).	2	1·5	2
<i>D. nudicaudata</i> (Rat-tailed „).	2	9	14
<i>D. opossum</i> (Quica „).	9	11	22
<i>D. philander</i> (Philander „).	4	4·7	9
<i>D. virginiana</i> (Virginian „).	12	8	16

The Opossums, which are omnivorous and carnivorous, display low maximum and average durations, and so far as this evidence goes would appear to have a relatively low potential longevity and a poor viability. On the other hand, they have been treated as animals requiring protection from cold at all costs, and have been kept in artificially warmed houses without access to the open air.

Summary of Marsupialia.

The records show in the first place that whilst within the different divisions of Marsupials, there is frequently a close correspondence between size and longevity, there is no such relation if the group be considered as a whole. The maximum duration was that of a Wombat which lived nearly 18 years in the Gardens; next comes a Kangaroo with a duration of 14 years; then some small Phalangers reaching nearly 12 years; then a Thylacine reaching nearly 9 years. It is notable that much the best records are in the case of animals which have had good access to air; the chief exception, and this only a doubtful one, is that of the Phalangers.

MONOTREMATA.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Echidna hystrix</i> (Echidna)	4	1.5	5

The records are sufficient only to show the failure, in the period in question, to provide suitable conditions for these animals. They have always been kept in artificially heated houses.

SUMMARY OF MAMMALIA.

It is advisable to repeat here that the material on which this communication is based, is defective in certain important respects. No information was available as to the condition of the animals on their arrival. I have tried to eliminate this source of error to a certain extent, by omitting in most cases entries of animals that had lived less than a month in the Gardens. Similarly, no information as to the age of entrants was available. It is obvious that the heavy incidence of mortality in very young animals is an important factor independent of the special conditions of captivity, whilst the possibility of duration is naturally less in old animals than in young adults. These defects probably have abnormally lowered the records of average and of maximum duration, but to what extent I am unable to guess. At the beginning of 1911, I put into operation a system suggested to me by my friend Mr. J. L. Bonhote, F.Z.S., and I hope that thirty years after this, someone will be in a position to institute an enquiry similar to the present communication to the Society, but based on more exact data. In every case where it is possible, a card is prepared for each new arrival at the Gardens; on the face is placed the name, and mode and date of acquisition of the animal; on the reverse is entered the first place of detention, the apparent condition of health, and any indications of age ("very young," "adult," or "old adult," unless exact particulars are known); the card follows the animal to each successive house in which it may come to be placed; the dates of such changes and any important events in its history are noted; finally, at the Prosectorium, the date and cause of death are entered, with any further data as to age that may be available.

In the meantime, however, it is possible to gain considerable information, at least of a comparative kind, from such records as I had at my disposal.

Uncertainty of age and varying conditions of health on arrival, and the abnormal conditions during detention, make it doubtful if the maximum durations at the Gardens give very reliable evidence as to the potential longevity of the species concerned. The following conclusions, however, have some foundation, at least if taken relatively. Amongst Primates, the Anthropoids have a lower potential longevity than man, and longevity decreases gradually towards the smallest monkeys, whilst in the case of Lemurs it rises considerably. The potential longevity of Carnivora is relatively high, and wherever the conditions are reasonably favourable, cases of long life in proportion to size are abundant. Insectivora have low potential longevity. Rodents have an unexpectedly high potential longevity, there being many cases of unusually great age, in proportion to size. Elephants and the larger Ungulates have low potential longevity in proportion to their size; all Ruminants have a relatively low potential longevity, and the correlation with size is absent, or almost reversed; in proportion to their size, many of the smaller forms, such as Sheep and Goats, are much longer lived than Giraffes, Elands, or Cattle. Edentates supply a number of examples pointing to a high potential longevity; whilst Marsupials generally, with exceptions, such as Wombats and Phalangers, have a relatively low potential longevity.

Metchnikoff has elaborated the view that a chief cause of senility is auto-intoxication from intestinal putrefaction, and that, on the whole, those animals with the most capacious cæca, large intestines and rectums, have the shortest lives in proportion to their size and organization. The inferences from the maximum and average durations recorded here, are in general agreement with this view; the number of instances of animals and groups of animals with relatively capacious hind-guts and short and fragile lives being very great. The most notable exceptions are some of the Rodents, for instance Squirrels and Porcupines, and some of the Marsupials, such as Wombats and Phalangers, which, although they have relatively capacious hind-guts, have relatively high viability and longevity. It must be noted, however, that if the data were such as to exclude the unfavourable effect of the special conditions in captivity, these exceptions might disappear. I think the general proposition is true, that in proportion to its size, an animal with a short hind-gut is hardier and has an expectation of longer life.

The most important inference that I draw from these records is the complete failure in practice of the theory that protection from cold by artificial heat is the fundamental requisite for mammals in captivity. In the long list of mammals, belonging to nearly every group, and coming from every part of the world, there is no case of the successful application of this method, that

is to say, there is no case where the maximum duration is near what might be expected, and the average duration bears a reasonable relation to the maximum. Individual exceptions, or knowledge from other sources, show us the ages to which animals may attain; the records show the complete failure to get near what is possible. Where comparative experiments have been made the contrast is amazing. Compare the large cats, which were relatively well housed, with the small cats, which were confined in an overheated house without access to open air; compare the civets, which were kept out of doors, with the genetids and paradoxures, kept in a heated house; the larger canines with the smaller forms; the rats and badgers (unheated) with other mustelines (heated); the raccoons (unheated) with coatis (heated); the squirrels and porcupines (unheated) with most of the other rodents (heated); the larger marsupials and wombats (unheated) with the smaller marsupials (heated).

The most fatal type of housing for any mammal (or bird) is being confined to the interior of a warmed house, without free access to the open air. The conditions of course are very complex, and I do not suggest that the provision of heat is in itself an evil. The ideal throughout the period I am discussing, and which still maintains an evil existence in the minds of a majority of those who have to do with living animals, is that, in the first place, animals have to be kept warm. Warmth having been secured, the more advanced persons have consented to, or even urged, the advantage of ventilation, moistening of the air, and so forth. The idea, however, is wrong. The first requisite is free access to the open air, the next is light, space and cleanliness; these things having been secured, any form of heating that may be thought advisable, may be added *in so far as it does not in any way interfere with the primary considerations*. So far as I can judge from my experience and observations, the maintenance of an equable temperature, and probably even a greater amount of heat than is usually provided, is important in the case of reptiles and of young or sick mammals or birds. Adult mammals and birds, if in a normal state of health and if provided with tolerable space for exercise, not only do not require an equable temperature, but thrive better if they are subjected to changes of temperature. The best possible conditions for them are free access to large open-air enclosures, with adequate wind-screens, and with the possibility of retreat to small, dry shelters, which may or may not be provided with some form of artificial heat. The smaller such shelters are the better, and certainly they should not be, whether heated or unheated, part of a building to which visitors have access. In a much larger number of cases than is generally supposed, if such shelters are small and dry, and provided with appropriate bedding, artificial heat is unnecessary.

Mammals and birds, if they have room for exercise in fresh air, not only can maintain the heat of their bodies, but as a direct reaction to the stimulation of air and change of temperature,

improve in general vitality and in the quality of their hair, fur, or feathers. Their viability is in a large measure determined by their power of resistance to bacterial and probably other parasites. It is impossible to ward off infection altogether, but the general condition of the body and exposure to light and air are the most certain preservatives.

It appears to be certain that although infection by a very few parasites (microscopic or macroscopic), as these are living creatures with the power of reproduction, is theoretically enough to contaminate an animal, yet, in actual practice, a fairly heavy bombardment of parasites is necessary. Confinement in heated houses not only weakens the natural power of resistance, but affords the greatest opportunity for heavy bombardment. Exposure to cold, light and air rapidly destroy a vast proportion of the parasites or their eggs or embryos that are not in actual occupation of their host, and warmed houses afford the best possible environment for them. I do not doubt, that by reducing artificial heating as much as possible, and by making the shelters as small and as easy to clean as possible, the damaging effect of parasitic infection could be reduced enormously.

AVES.

PASSERES.

TURDIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Turdus</i> , whole genus	68	46·7	154
<i>T. albiventris</i> (White-bellied Thrush) ..	2	10·5	20
<i>T. cardis</i> (Grey Thrush)	2	52·5	64
<i>T. falklandicus</i> (Falkland Island Thrush) ..	1	32	32
<i>T. flavipes</i> (Brazilian Grey Ousel) ...	1	30	30
<i>T. iliacus</i> (Redwing)	9	40	75
<i>T. leucomelas</i> (Brown Thrush)	5	67	119
<i>T. merula</i> (Blackbird)	7	59	135
<i>T. migratorius</i> (American Robin)	11	61	154
<i>T. musicus</i> (Song-Thrush)	4	74	137
<i>T. mustelinus</i> (Wood-Thrush)	4	14	29
<i>T. pæcilopecterus</i> (Grey-winged Blackbird) ..	1	12	12
<i>T. pilaris</i> (Fieldfare)	8	29	53
<i>T. rufiventris</i> (Red-bellied Thrush) ...	3	67	95
<i>T. torquatus</i> (Ring-Ousel)	5	47	93
<i>T. tristis</i> (Sorry Thrush)	2	57	103
<i>T. viscivorus</i> (Missel Thrush)	3	8	12
<i>Geocichla citrina</i> (Orange-headed Ground Thrush) ..	2	27	50
<i>G. wardi</i> (Pied Ground Thrush)	1	12	12
<i>Monticola cyanus</i> (Solitary Thrush) ...	7	18	46
<i>M. saxatilis</i> (Rock ") ..	6	24·5	40
<i>Myiophonus horsfieldi</i> (Horsfield's Whistling Thrush) ..	1	62	62

TURDIDÆ (cont.).	No. of Indiv.	Max. dur. in months.	Av. dur in months
<i>Saxicola cenanthe</i> (Wheatear)	11	12	62
<i>Pratincola rubetra</i> (Whinchat).....	7	9	22
<i>Ruticilla phœnicurus</i> (Redstart)	4	4	7
<i>R. tithys</i> (Black Redstart).....	1	4	4
<i>Cyanecula suecica</i> (Blue-throat)	1	27	27
<i>Erithacus rubecula</i> (Red-breast)	4	10	16
<i>Miro albifrons</i> (South Island Robin) .	4	9	28
<i>Copsychus saularis</i> (Indian Dial-Bird).	9	39	133
<i>Cittocinclia macrura</i> (Indian Shama)...	4	46	53
<i>Sialia wilsoni</i> (Common Bluebird) ...	29	20	54
<i>Daulias lusciniæ</i> (Nightingale).....	21	16	45
<i>Sylvia</i> , whole genus	21	9	27
<i>S. atricapilla</i> (Blackcap)	13	10	27
<i>S. cinerea</i> (Whitethroat)	3	9	20
<i>S. curruca</i> (Lesser Whitethroat)	3	8	14
<i>S. sylvicola</i> (Wood Warbler).....	1	5	5
<i>S. trochilus</i> (Willow „).....	1	2	2
<i>Acrocephalus streperus</i> (Reed-Warbler).	1	5	5
<i>Accentor collaris</i> (Alpine Accentor) ...	11	23	52
<i>A. modularis</i> (Wood Sparrow)	1	41	41
<i>Mimus polyglottus</i> (Northern Mocking Bird).	26	23	79
<i>M. saturninus</i> (Saturnine Mocking Bird).	3	31	47
<i>Galeoscoptes carolinensis</i> (Cat-bird) ...	3	19	51
<i>Harporhynchus rufus</i> (Brown Mock Thrush).	3	31	71
<i>Cichlherminia densirostris</i> (White-eyed Mock Thrush).	1	16	16
CINCLIDÆ.			
<i>Cinclus aquaticus</i> (Dipper)	7	7	26
PANURIDÆ.			
<i>Panurus biarmicus</i> (Bearded Tit- mouse).	14	8	31
PARIDÆ.			
<i>Parus</i> , whole genus	55	18	108
<i>P. ater</i> (Coal Titmouse).....	4	16	30
<i>P. borealis</i> (Northern Titmouse).....	5	32	73
<i>P. caudatus</i> (Long-tailed „).....	2	4	5
<i>P. ceruleus</i> (Blue „).....	9	18	29
<i>P. cristatus</i> (Crested „).....	2	15	2
<i>P. cyaneus</i> (Azure „).....	3	11	12
<i>P. major</i> (Great „).....	14	21	108
<i>P. palustris</i> (Marsh „).....	3	18	40
<i>P. varius</i> (Red-sided „).....	13	15	36
<i>Liothrix luteus</i> (Yellow-bellied Liothrix).	41	27	100

SITTIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sitta cæsia</i> (Common Nuthatch)	11	10	57

MOTACILLIDÆ.

<i>Motacilla</i> , whole genus	28	17	60
<i>M. flava</i> (Blue-headed Wagtail)	7	11	27
<i>M. lugubris</i> (Pied ")	10	12	45
<i>M. melanope</i> (Grey ")	8	24	60
<i>M. raii</i> (Yellow ")	3	33	51
<i>Anthus</i> , whole genus	10	13·8	43
<i>A. arboreus</i> (Tree Pipit).....	4	14	24
<i>A. obscurus</i> (Rock ").....	2	28·5	43
<i>A. pratensis</i> (Meadow Pipit)	3	7	18
<i>A. spipoletta</i> (Water ").....	1	2	2
<i>Grallina australis</i> (Australian Pipit) .	2	11	20

PYCNONOTIDÆ.

<i>Pycnonotus</i> , whole genus	41	31	132
<i>P. atricapillus</i> (Black-capped Bulbul). 1	12	12	
<i>P. crocorrhous</i> (Yellow-vented ") . 1	15	15	
<i>P. hæmorrhous</i> (Red-vented ") . 12	46	132	
<i>P. jocosus</i> (Red-eared ") . 10	26·6	79	
<i>P. leucotis</i> (White-eared ") . 8	32·3	91	
<i>P. sinensis</i> (Syrian ") . 4	11	23	
<i>P. xanthopygos</i> (Chinese ") . 5	24	83	
<i>Hemixos flava</i> (Brown-eared ") . 3	27	62	
<i>Hypsipetes maclellandi</i> (Rufous-bellied Bulbul). 2	77	114	
<i>Chloropsis aurifrons</i> (Malabar Green Bulbul). 3	22	39	
<i>C. hardwickii</i> (Blue-winged Bulbul) ... 1	130	130	

CRATEROPODIDÆ.

<i>Garrulax</i> , whole genus	26	50	107
<i>G. albugularis</i> (White-throated Jay-Thrush). 3	15	77	
<i>G. chinensis</i> (Chinese Jay-Thrush) ... 11	61	107	
<i>G. leucolophus</i> (White-crested Jay-Thrush). 7	47	98	
<i>G. pectoralis</i> (Black-gorgetted Jay-Thrush). 2	31	42	
<i>G. perspicillatus</i> (Masked Jay-Thrush). 2	91	103	
<i>G. picticollis</i> (Collared ") . 1	97	97	
<i>Turnagra crassirostris</i> (South Island Thrush). 5	15·4	26	
<i>Sibia capistrata</i> (Black-headed Sibia) . 3	44	61	
<i>Leucodioptron canorum</i> (Melodious Jay-Thrush). 6	30	81	

CRATEROPODIDÆ (cont.).			
	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Grammatoptila striata</i> (Striated Jay-Thrush).	4	8	14
<i>Struthidea cinerea</i> (Grey Struthidea).	5	93	223
<i>Hypocolius ampelinus</i> (Grey Hypocolius).	4	56	68

ORIOLIDÆ.

<i>Sericulus melinus</i> (Regent Bird)	5	33	84
<i>Oriolus</i> , whole genus	5	12	31
<i>O. indicus</i> (Black-naped Oriole)	1	14	14
<i>O. kundoo</i> (Sykes's ")	3	15	31
<i>O. melanocephalus</i> (Black-headed Oriole)	1	1	1

DICRURIDÆ.

<i>Chibia hottentotta</i> (Indian Drongo) ...	1	4	4
<i>Artamus</i> , whole genus	12	15.6	20
<i>A. fuscus</i> (Dull Wood Swallow)	1	8	8
<i>A. personata</i> (Masked Wood Swallow).	1	20	20
<i>A. sordidus</i> (Sordid " ")	4	13	20
<i>A. superciliosus</i> (White-eyebrowed Wood Swallow).	6	18	32

LANIIDÆ.

<i>Lanius</i> , whole genus	19	13.6	78
<i>L. collurio</i> (Red-backed Shrike)	13	12	49
<i>L. excubitor</i> (Great Grey ")	5	4.6	21
<i>L. lahtora</i> (Indian " ")	1	78	78
<i>Laniarius quadricolor</i> (Four-coloured Shrike).	1	3	3
<i>Cochoa viridis</i> (Green Cochoa)	1	34	34

AMPELIDÆ.

<i>Ampelis cedrorum</i> (Cedar Bird)	1	14	14
<i>A. garrulus</i> (Waxwing)	18	8.5	39

MUSCICAPIDÆ.

<i>Muscicapa atricapilla</i> (Pied Flycatcher).	1	3	3
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HIRUNDINIDÆ.

<i>Hirundo rustica</i> (Swallow)	2	1	2
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NECTARINIIDÆ.

<i>Zosterops</i> , whole genus	18	21	87
<i>Z. dorsalis</i> (Grey-backed White-eye) .	2	24	46
<i>Z. lateralis</i> (Lateral " ") .	12	11	25
<i>Z. palpebrosus</i> (Indian " ") .	2	70	87
<i>Z. simplex</i> (Chinese " ") .	2	29.5	58

MELIPHAGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Prothemadera novæ-zealandiæ</i> (Poë Honey-eater).	19	14	58
<i>Myzantha garrula</i> (Garrulous „).	1	9	9
<i>Anthornis melanura</i> (Black-tailed Flower-bird).	5	6·4	13
<i>Xanthomyza phrygia</i> (Warty-faced Honey-eater).	5	19	37
<i>Entomyza cyanotis</i> (Blue-faced Honey- eater).	4	5	12
CEREBIDÆ.			
<i>Cereba cyanea</i> (Yellow-winged Sugar- bird).	26	24·4	92
<i>Dacnis cyana</i> (Blue Sugar-bird)	4	11·5	18
<i>Chlorophonia spiza</i> (Black-headed Sugar-bird).	2	42·5	84
TANAGRIDÆ.			
<i>Chlorophonia viridis</i> (All-green Tanager). 6		3	4
<i>Euphonia</i> , whole genus	41	12·5	39
<i>E. chlorotica</i> (Greenish Tanager)	1	1	1
<i>E. flavifrons</i> (Yellow-fronted Tanager).	2	16	30
<i>E. lanirostris</i> (Thick-billed „).	9	11	39
<i>E. nigricollis</i> (Black-necked „).	4	7·5	10
<i>E. pectoralis</i> (Pectoral „).	1	8	8
<i>E. sclateri</i> (Sclater's „).	1	1	1
<i>E. violacea</i> (Violet „).	23	15	34
<i>Hypophæa chalybea</i> (Lead-coloured Tanager).	1	11	11
<i>Tanagrella cyanomelæna</i> (Blue & Black Tanager).	2	14·5	15
<i>T. velia</i> (Red-bellied Tanager)	1	2	2
<i>Calliste</i> , whole genus	32	11·5	39
<i>C. brasiliensis</i> (Brazilian Tanager)	3	5	8
<i>C. fastuosa</i> (Superb Tanager)	13	15	39
<i>C. festiva</i> (Festive „)	3	4	4
<i>C. melanota</i> (Black-shouldered Tanager).	2	5	6
<i>C. tricolor</i> (Green-headed Tanager)...	11	11·8	33
<i>Tanagra</i> , whole genus	24	16	70
<i>T. cana</i> (Silver-blue Tanager)	3	12	23
<i>T. cyanopectera</i> (Blue-shouldered Tanager)	7	18	49
<i>T. palmarum</i> (Palm Tanager)	5	11	33
<i>T. sayaca</i> (Sayacu „)	2	7	11
<i>T. striata</i> (Striated „)	7	21	70
<i>Stephanophorus leucocephalus</i> (White- capped Tanager)	2	3	4
<i>Tachyphonus coronatus</i> (Crowned Tanager).	1	8	8
<i>T. melaleucus</i> (Black Tanager)	8	22	47

TANAGRIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pyrranga saira</i> (Saira Tanager)	2	3·5	5
<i>Rhamphocelus brasilius</i> (Brazilian Tanager).	13	46	88
<i>Cissopis leveriana</i> (Magpie Tanager) .	9	30	87
<i>Saltator aurantirostris</i> (Orange-bellied Tanager).	1	75	75
<i>S. magnus</i> (Great Tanager)	1	3	3
<i>S. similis</i> (Allied ")	2	10	19
<i>Orchesticus ater</i> (Black-headed Tanager).	1	66	66

PLOCEIDÆ.

<i>Estrela</i> , whole genus	176	28·5	98
<i>E. amandava</i> (Amaduvade Finch)	30	31	98
<i>E. bella</i> (Beautiful Finch)	6	5	8
<i>E. bichenovii</i> (Bicheno's Finch)	8	7·5	21
<i>E. cinerea</i> (Common Waxbill)	21	45	93
<i>E. cærulescens</i> (Cinereous ")	5	27	93
<i>E. cyanogastra</i> (Blue-breasted Waxbill)	6	25	57
<i>E. dufresnii</i> (Dufresne's ")	10	23·7	63
<i>E. formosa</i> (Green ")	16	20	44
<i>E. granatina</i> (Grenadier ")	1	38	38
<i>E. melpoda</i> (Orange-cheeked ")	17	32	84
<i>E. phœnicotis</i> (Crimson-eared ")	8	21	34
<i>E. phæton</i> (Crimson ")	6	14·5	38
<i>E. rubriventris</i> (Red-bellied ")	21	37	88
<i>E. squamifrons</i> (Scaly-fronted ")	4	9	12
<i>E. subflava</i> (Zebra ")	7	35	84
<i>E. temporalis</i> (Australian ")	10	23·9	74
<i>Spermestes</i> , whole genus	26	30	85
<i>S. cucullata</i> (Hooded Finch)	10	30	47
<i>S. fringilloides</i> (Pied Grass-Finch) ...	12	21	80
<i>S. nana</i> (Dwarf Finch)	4	55	85
<i>Pytelia</i> , whole genus	9	14·5	43
<i>P. citerior</i> (Western Melba Waxbill)...	1	1	1
<i>P. phœnicoptera</i> (Crimson-winged Waxbill).	6	12	29
<i>P. wieneri</i> (Wiener's Finch)	2	27·5	43
<i>Amadina</i> , whole genus	78	27	99
<i>A. bicolor</i> (Cape Palmas Finch)	3	33	58
<i>A. castanotis</i> (Chestnut-eared Finch)	27	42	99
<i>A. erythrocephala</i> (Red-headed ")	7	21	38
<i>A. fasciata</i> (Cut-throat ")	5	24	42
<i>A. fringilloides</i> (Fringillid ")	1	22	22
<i>A. lathamii</i> (Spotted-sided ")	23	14	52
<i>A. modesta</i> (Modest ")	12	22	67
<i>Munia</i> , whole genus	75	37·5	123
<i>M. ferruginea</i> (Javan Maja Finch) ...	1	61	61

PLOCEIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Munia maja</i> (Maja Finch) ...	6	56	101
<i>M. malabarica</i> (Indian Silver-bill) ...	18	30	115
<i>M. malacca</i> (Black-headed Finch).....	6	30	109
<i>M. nisoria</i> (Bar-breasted „).....	11	54	123
<i>M. punctularia</i> (Nutmeg-Bird)	10	41	75
<i>M. rubro-nigra</i> (Chestnut-bellied Finch).	12	33	89
<i>M. striata</i> (Striated Finch)	5	30	57
<i>M. topela</i> (Topela „)	6	21	82
<i>Poëphila</i> , whole genus.....	53	23	82
<i>P. acuticauda</i> (Long-tailed Grass-Finch)	5	22	67
<i>P. cincta</i> (Banded „ „)	21	20	74
<i>P. gouldiae</i> (Gouldian „ „)	14	27	82
<i>P. mirabilis</i> (Beautiful „ „)	13	22·7	79
<i>Donacola castaneothorax</i> (Chestnut- breasted Finch).	16	20	44
<i>D. pectoralis</i> (White-breasted „)	2	8·6	15
<i>Padda oryzivora</i> (Java Sparrow)	14	54	159
<i>Erythrura prasina</i> (Fire-tailed Finch)	4	10	12
<i>E. psittacea</i> (Parrot „)	4	7·5	11
<i>Vidua</i> , whole genus.....	47	25	199
<i>V. albonotata</i> (White-marked Whydah Bird).	1	13	13
<i>V. ardens</i> (Red-chested Whydah Bird)	2	27·5	28
<i>V. paradisea</i> (Paradise „ „)	32	28	199
<i>V. principalis</i> (Pin-tailed „ „)	12	16	81
<i>Chera progne</i> (Long-tailed Weaver- bird).	4	13	17
<i>Hypochera nitens</i> (Shining Weaver-bird)	5	72	124
<i>Coliopasser macrurus</i> (Yellow-backed Whydah Bird).	4	85	239
<i>Urobrachya</i> , whole genus	9	23	107
<i>U. albonotata</i> (White-winged Whydah Bird).	5	35	107
<i>U. axillaris</i> (Red-shouldered Weaver- bird).	2	45	71
<i>U. bocagii</i> (Orange-shouldered Weaver- bird).	2	21·5	26
<i>Euplectes</i> , whole genus	70	40	131
<i>E. afer</i> (Black-bellied Weaver-bird).	6	31	106
<i>E. capensis</i> (Yellow-shouldered Weaver- bird).	9	60	98
<i>E. flammiceps</i> (Crimson-crowned Weaver-bird).	14	71	131
<i>E. nigriventris</i> (Black-chested „)	2	36·5	60
<i>E. oryx</i> (Grenadier „)	39	26	119
<i>Pyromelana aurea</i> (Golden-backed Weaver-bird).	4	22	57

PLOCEIDÆ (cont).		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pyromelana</i>	<i>franciscana</i> (Scarlet Weaver-bird.)	2	62	85
<i>Foudiaerythrops</i>	(Red-faced " ")	8	48	102
<i>F. madagascariensis</i>	(Red-headed Weaver-bird).	12	31	64
<i>Pyrenestes albifrons</i>	(White-fronted Weaver-bird).	2	71	83
<i>Spermospiza hæmatina</i>	(Blue-beaked Weaver-bird).	3	27	55
<i>S. guttata</i>	(Bright-spotted " ")	2	40.5	45
<i>Quelea</i>	whole genus	38	51	130
<i>Q. occidentalis</i>	(Black-cheeked Weaver-bird.)	3	63	78
<i>Q. russi</i>	(Russ's Weaver-bird)	6	45	121
<i>Q. sanguinirostris</i>	(Red-beaked " ")	29	48	130
<i>Ploceus</i>	whole genus	16	28	60
<i>P. atrigula</i>	(Black-throated Weaver-bird).	3	18	28
<i>P. bengalensis</i>	(Bengal Weaver-bird)	3	15	29
<i>P. manyar</i>	(Manyar " ")	10	34	60
<i>Heterhyphantes melanogaster</i>	(Black-chested Weaver-bird).	1	122	122
<i>Sitagra luteola</i>	(Yellowish " ")	2	67	71
<i>Hyphantornis</i>	whole genus	46	48	189
<i>H. brachyptera</i>	(Short-winged Weaver-bird).	1	10	10
<i>H. capensis</i>	(Olive Weaver-bird)	9	35	124
<i>H. castaneofuscus</i>	(Chestnut-backed Weaver-bird).	3	23	38
<i>H. nigriceps</i>	(Black-headed " ")	2	55	110
<i>H. personata</i>	(Masked " ")	5	57	138
<i>H. superciliosus</i>	(Eye-browed " ")	1	46	46
<i>H. textor</i>	(Rufous-necked " ")	17	59	189
<i>H. velatus</i>	(Black-fronted " ")	8	46	83
<i>Textor alector</i>	(Ox-bird)	1	70	70

FRINGILLIDÆ.

<i>Cyanospiza ciris</i>	(Nonpareil Finch) ...	13	20.8	56
<i>C. cyanea</i>	(Indigo-bird)	7	24	45
<i>Phonipara canora</i>	(Melodious Finch)...	5	33	43
<i>P. olivacea</i>	(Olive Finch)	2	19	27
<i>Paroaria</i>	whole genus	38	38.9	101
<i>P. capitata</i>	(Yellow-billed Cardinal) ...	6	13.5	30
<i>P. cucullata</i>	(Red-crested " ")...	25	44	101
<i>P. larvata</i>	(Red-headed " ")...	7	40	76
<i>Gubernatrix cristatellus</i>	(Black-crested Cardinal).	11	34	108
<i>Diuca grisea</i>	(Diuca Finch)	11	43	189

FRINGILLIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Phrygilus</i> , whole genus	4	31	86
<i>P. alaudinus</i> (Alaudine Finch)	1	86	86
<i>P. fruticeti</i> (Orchard ")	1	15	15
<i>P. gayi</i> (Gay's ")	2	27	37
<i>Guiraca</i> , whole genus	12	21	71
<i>G. cerulea</i> (Blue Grosbeak)	2	26	35
<i>G. cyanea</i> (Brazilian Blue Grosbeak)... ..	8	19	71
<i>G. parellina</i> (Lazuline Finch)	2	25	45
<i>Hedymeles ludovicianus</i> (Rose-breasted Grosbeak).	2	7	11
<i>Pheucticus chrysogaster</i> (Yellow-bellied Grosbeak).	1	37	37
<i>Cardinalis virginianus</i> (Cardinal ")	21	31	83
<i>Oryzoborus crassirostris</i> (Thick-billed Seed-Finch).	1	53	53
<i>O. torridus</i> (Tropical " ")	7	21	49
<i>Coryphospingus cristatus</i> (Red-crested Finch).	8	47	123
<i>C. pileatus</i> (Pileated Finch)	5	14	40
<i>Spermophila</i> , whole genus	50	43.5	127
<i>S. albogularis</i> (White-throated Finch)	5	83	123
<i>S. cerulescens</i> (Bluish ")	7	43	78
<i>S. collaria</i> (Collared ")	2	109	127
<i>S. euleri</i> (Euler's ")	2	2	2
<i>S. gutturalis</i> (Guttural ")	2	30.5	34
<i>S. hypoleuca</i> (Half-white ")	2	16.5	33
<i>S. lineata</i> (Lineated ")	2	66	88
<i>S. lineola</i> (Lined ")	18	36	110
<i>S. nigro-aurantia</i> (Reddish ")	3	45	101
<i>S. plumbea</i> (Plumbeous ")	6	36	85
<i>S. torqueola</i> (Black-banded ")	1	3	3
<i>Passer</i> , whole genus	25	22	135
<i>P. alario</i> (Alario Sparrow)	12	8	16
<i>P. arcuatus</i> (Cape ")	1	21	21
<i>P. diffusus</i> (Black-breasted Sparrow)... ..	1	19	19
<i>P. luteus</i> (Yellow ")	5	40	124
<i>P. montanus</i> (Tree ")	2	16	19
<i>P. salicicola</i> (Spanish ")	1	38	38
<i>P. simplex</i> (Grey-headed ")	3	45	135
<i>Petronia petronella</i> (Yellow-throated Rock-Sparrow).	7	9.7	17
<i>P. stulta</i> (Rock-Sparrow)	2	46	91
<i>Coccothraustes</i> , whole genus	31	22.5	92
<i>C. melanurus</i> (Black-tailed Hawfinch)	8	34	74
<i>C. personatus</i> (Masked ")	2	12.5	24
<i>C. vulgaris</i> (Hawfinch)	21	19	92
<i>Mycerobas melanocephalus</i> (Black and Yellow Hawfinch).	1	44	44
<i>Ligurinus chloris</i> (Greenfinch)	2	38	66

FRINGILLIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Ligurinus sinicus</i> (Japanese Green-finch).....	5	27	85
<i>Montifringilla nivalis</i> (Snow-Finch)....	2	21.5	37
<i>Fringilla</i> , whole genus	43	36	142
<i>F. caelebs</i> (Chaffinch)	7	33	142
<i>F. kawarahiba</i> (Kawahariba Finch) ...	2	42	55
<i>F. linaria</i> (Mealy Redpoll)	1	89	89
<i>F. montifringilla</i> (Brambling)	22	45	105
<i>F. spodiogenia</i> (Alpine Chaffinch).....	2	23	24
<i>F. teydea</i> (Teydean ").....	5	10	22
<i>F. tintillon</i> (Tintillon ").....	4	23	60
<i>Carduelis elegans</i> (Goldfinch).....	21	24	57
<i>C. orientalis</i> (Eastern ").....	3	18	43
<i>Chrysomitris</i> , whole genus	33	13	90
<i>C. barbatus</i> (Black-chinned Siskin) ...	5	1.4	4
<i>C. spinoides</i> (Indian ") ...	1	90	90
<i>C. spinus</i> (Siskin)	23	12	74
<i>C. tristis</i> (American Siskin)	3	11	32
<i>C. yarrelli</i> (Yarrell's ")	1	24	24
<i>Sycalis</i> , whole genus	32	27	90
<i>S. arvensis</i> (Field Saffron Finch)	2	33	52
<i>S. flaveola</i> (" ")	22	24	90
<i>S. luteola</i> (Yellowish ")	8	31	80
<i>Cyithagra</i> , whole genus	34	24	90
<i>C. albogularis</i> (White-throated Seed-eater).	6	10	30
<i>C. butyracea</i> (Yellow Seed-eater).....	10	22	90
<i>C. chrysopyga</i> (Yellow-rumped ") ..	13	38	80
<i>C. musicus</i> (Singing ")	2	17	24
<i>C. sulphurata</i> (Sulphury ")	3	2	4
<i>Serinus</i> , whole genus	18	15	52
<i>S. angolensis</i> (Angolan Serin)	1	22	22
<i>S. canarius</i> (Canary).....	12	14	52
<i>S. canicollis</i> (Grey-necked Serin)	1	20	20
<i>S. hortulanus</i> (Serin)	3	10.3	24
<i>S. tottus</i> (Brown Canary)	1	27	27
<i>Linota</i> , whole genus	28	21	92
<i>L. cannabina</i> (Linnet)	3	14	24
<i>L. flavirostris</i> (Twite).....	4	39	92
<i>L. rufescens</i> (Lesser Redpoll).....	21	18.5	74
<i>Carpodacus erythrinus</i> (Ruddy Finch) ..	13	28	79
<i>C. hæmorrhous</i> (Blood-stained ") ..	4	25	49
<i>Erythropsiza githaginea</i> (Rosy Bullfinch) ..	6	27	52
<i>Pyrhrhula europæa</i> (Bullfinch).....	8	12	41
<i>P. rubicilla</i> (Siberian Bullfinch)	7	12	23
<i>Pinicola enucleator</i> (Pine-Grosbeak) ...	10	13	44
<i>Loxia</i> , whole genus.....	29	8	39
<i>L. pityopsittacus</i> (Parrot Crossbill) ...	3	24	39
<i>L. leucoptera</i> (White-winged Crossbill) ..	4	12	37

FRINGILLIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Loxia curvirostra</i> (Common Crossbill).	21	6	24
<i>L. bifasciata</i> (European White-winged Crossbill).	1	5	5
<i>Plectrophenax nivalis</i> (Snow Bunting)	63	11.5	65
<i>Calcarius lapponicus</i> (Lapland ")	4	18	30
<i>Emberiza</i> , whole genus	86	36	165
<i>E. aureola</i> (Yellow-breasted Bunting)	4	85.5	115
<i>E. cia</i> (Meadow ")	1	7	7
<i>E. ciopsis</i> (Bonaparte's ")	1	11	11
<i>E. cirrus</i> (Cirl ")	17	21	63
<i>E. citrinella</i> (Yellow Hammer)	5	27	77
<i>E. chrysophrys</i> (Yellow-browed Bunting)	2	53	86
<i>E. hortulana</i> (Ortolan ")	9	25	75
<i>E. luteola</i> (Red-headed ")	11	63	165
<i>E. melanocephala</i> (Black-headed ")	7	52	141
<i>E. miliaria</i> (Corn ")	6	45	123
<i>E. rutila</i> (Red-backed ")	5	50	149
<i>E. schoeniclus</i> (Reed ")	16	20	62
<i>E. striolata</i> (Striolated ")	2	15	21
<i>Euspiza americana</i> (American ")	3	15	23
<i>Fringillaria saharae</i> (Sahara ")	2	25.5	38
<i>Melophus melanicterus</i> (Crested Black Bunting).	2	12.5	24
<i>Zonotrichia albicollis</i> (White-throated Song Sparrow).	2	73	97
<i>Z. pileata</i> (Pileated " ")	13	17	42
<i>Junco hyemalis</i> (Snow-bird)	7	17	72
<i>Spizella socialis</i> (Chipping Sparrow) ...	1	8	8
<i>Pipilo erythrophthalmus</i> (Red-eyed Ground-Finch).	4	25	45
ICTERIDÆ.			
<i>Ostinops decumanus</i> (Crested Hangnest).	2	21	28
<i>Cassicus hæmatorrhous</i> (Red-rumped Hangnest).	2	41	57
<i>C. persicus</i> (Yellow ")	11	46	102
<i>Icterus</i> , whole genus	31	27	110
<i>I. abeillæi</i> (Black-sided Hangnest) ...	1	30	30
<i>I. baltimore</i> (Baltimore ") ...	5	14	38
<i>I. chryscephalus</i> (Yellow-crowned Tropical Hangnest).	1	66	66
<i>I. jamaici</i> (Brazilian Hangnest)	7	40	80
<i>I. spurius</i> (Orchard ")	6	17	31
<i>I. tibialis</i> (Yellow-shouldered Hangnest).	3	27	45
<i>I. vulgaris</i> (Common Hangnest)	8	27	110
<i>Dolichonyx oryzivora</i> (American Rice-bird).	1	3	3

ICTERIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Molothrus</i> , whole genus	25	65	145
<i>M. badius</i> (Bay Cow-bird)	5	67	145
<i>M. bonariensis</i> (Silky „)	18	65	135
<i>M. purpurascens</i> (Purple „)	2	52	71
<i>Agelæus</i> , whole genus	8	44	94
<i>A. frontalis</i> (Chestnut-fronted Troupial). 1	1	16	16
<i>A. phœniceus</i> (Red-shouldered Starling) 5	5	54	94
<i>A. ruficapillus</i> (Red-headed Marsh- bird) 2	2	33	65
<i>Xanthocephalus icterocephalus</i> (Yellow- headed Troupial). 11	11	47	123
<i>Xanthosomus flavus</i> (Yellow „) 3	3	53	98
<i>Amblyramphus holosericeus</i> (Silky Hangnest). 7	7	50	122
<i>Pseudoleistes virescens</i> (Dark-green Maize-eater). 5	5	26	55
<i>Sturnella defilippi</i> (De Filippi's Meadow-Starling). 18	18	16	39
<i>S. ludoviciana</i> (Louisianian „ „) 2	2	10·5	16
<i>Curæus aterrimus</i> (Chilian Starling)... 1	1	24	24
<i>Lamprosar dives</i> (Rich-black Troupial). 1	1	2	2
<i>Quiscalus lugubris</i> (Black „) 1	1	2	2
<i>Q. versicolor</i> (Changeable „) 9	9	10	31
<i>Aphobus chopi</i> (Chopi Starling) 3	3	62	102

STURNIDÆ.

<i>Lamprocolius auratus</i> (Purple-headed Glossy Starling). 3	3	141	155
<i>L. chalybeus</i> (Green „ „) 5	5	71	150
<i>Lamprotornis æneus</i> (Long-tailed Glossy Starling). 6	6	44	77
<i>Sturnus menzbieri</i> (Indian Starling) 2	2	25	26
<i>S. vulgaris</i> (Common „ „) 9	9	26	58
<i>Sturnopastor contra</i> (Pied Mynah) ... 3	3	59	107
<i>Acridotheres</i> , whole genus 25	25	44	145
<i>A. cristatellus</i> (Chinese Mynah) 6	6	34	62
<i>A. fuscus</i> (Brown „ „) 6	6	42	145
<i>A. ginginianus</i> (Indian „ „) 1	1	41	41
<i>A. mahrattensis</i> (Southern Brown Mynah). 2	2	58	97
<i>A. tristis</i> (Common Mynah) 10	10	47·8	117
<i>Poliopsar</i> , whole genus 8	8	30	97
<i>P. andamanensis</i> (Andaman Starling). 2	2	20·5	38
<i>P. blythi</i> (Blyth's „ „) 1	1	23	23
<i>P. malabaricus</i> (Malabar Mynah) ... 5	5	33	97
<i>Temenuchus pagodarum</i> (Black-headed Mynah). 1	1	13	13

STURNIDÆ (cont.).		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pastor roseus</i> (Rose-coloured Pastor)		24	34	97
<i>Gracupica nigricollis</i> (Black-necked Grackle).		1	16	16
<i>Dilophus carunculatus</i> (Wattled Starling).		6	42	73
<i>Gracula</i> , whole genus		39	30	124
<i>G. intermedia</i> (Larger Hill Mynah) ...		20	33	124
<i>G. javanensis</i> (Javan Mynah)		1	77	77
<i>G. religiosa</i> (Small Hill Mynah)		18	22	61
PTILONORHYNCHIDÆ.				
<i>Ptilonorhynchus smithi</i> (Green Bower Bird).		1	19	19
<i>P. violaceus</i> (Silky Bower Bird)		35	30	115
<i>Chlamydodera maculata</i> (Spotted Bower Bird).		5	40	68
PARADISEIDÆ.				
<i>Paradisea minor</i> (Lesser Bird of Paradise).		5	30	65
<i>P. rubra</i> (Red Bird of Paradise)		1	4	4
<i>Ptilorhis paradisea</i> (Rifle-bird)		1	46	46
<i>Seleucides nigricans</i> (Twelve-wired Bird of Paradise).		1	11	11
<i>Manucodia chalybea</i> (Green Manucode)		1	12	12
CORVIDÆ.				
<i>Corvus</i> , whole genus	140	24.6	133	
<i>C. americanus</i> (American Crow)	1	51	51	
<i>C. australis</i> (Australian „)	7	32	82	
<i>C. capellanus</i> (Chaplain „)	23	22	89	
<i>C. corax</i> (Raven)	31	11	47	
<i>C. cornix</i> (Hooded Crow)	14	35	99	
<i>C. corone</i> (Carrion „)	12	15	46	
<i>C. culminatus</i> (Long-billed Crow) ...	2	20	36	
<i>C. dauricus</i> (Black-and-white Jackdaw).	1	20	20	
<i>C. frugilegus</i> (Rook)	13	10	27	
<i>C. monedula</i> (Jackdaw)	15	39	89	
<i>C. scapulatus</i> (White-necked Crow) ...	10	21	113	
<i>C. splendens</i> (Indian „) ...	11	38	133	
<i>Corvultur albicollis</i> (White-necked Raven).	1	18	18	
<i>Nucifraga caryocatactes</i> (Nutcraacker) .	6	27	93	
<i>Pica</i> , whole genus	19	51	131	
<i>P. bootanensis</i> (Himalayan Magpie) ..	1	6	6	
<i>P. mauritanica</i> (Moorish „) ...	1	9	9	
<i>P. rustica</i> (Magpie)	15	54	131	
<i>P. sericea</i> (Chinese Magpie)	2	69	83	

CORVIDÆ (cont.).		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cyanopolius cooki</i> (Spanish Blue Magpie).		36	24	75
<i>C. cyaneus</i> (Chinese Blue Magpie) ...		8	31.5	84
<i>Garrulus glandarius</i> (Jay)		20	12.8	41
<i>G. lanceolatus</i> (Lanceolated Jay)		5	46	80
<i>Cyanocitta</i> , whole genus		17	25	94
<i>C. coronata</i> (Crowned Jay)		2	4.5	6
<i>C. cristata</i> (Blue ")		10	20	54
<i>C. melanocyanea</i> (Guatemala Blue Jay).		1	16	16
<i>C. yucatanica</i> (Yucatan " ")		4	51	94
<i>Cyanocorax</i> , whole genus		62	12.5	77
<i>C. cyanomelas</i> (Black-headed Jay) ...		1	3	3
<i>C. lucuosus</i> (Mexican ") ...		2	19.5	29
<i>C. cyanopogon</i> (Blue-bearded ") ...		40	11.5	77
<i>C. pileatus</i> (Pileated ") ...		19	14	32
<i>Calocitta formosa</i> (Swainson's Long- tailed Jay),		3	16	29
<i>Urocissa</i> , whole genus		14	27	89
<i>U. flavirostris</i> (Yellow-billed Blue Pie)		2	17.5	18
<i>U. magnirostris</i> (Siamese " ")		8	15	45
<i>U. occipitalis</i> (Occipital " ")		2	17	25
<i>U. sinensis</i> (Chinese " ")		2	87	89
<i>Cissa venatoria</i> (Hunting Crow)		6	21	56
<i>Dendrocitta</i> , whole genus		14	27	109
<i>D. himalayensis</i> (Himalayan Tree Pie)		4	22.5	40
<i>D. sinensis</i> (Chinese " ")		5	38	109
<i>D. vagabunda</i> (Wandering " ")		5	21	30
<i>Ptilostomus senegalensis</i> (Piapec)		2	32.5	41
<i>Pyrrhocorax alpinus</i> (Alpine Chough).		10	40.6	87
<i>P. graculus</i> (Chough)		5	41.4	94
<i>Corcorax melanorhamphus</i> (White- winged Chough).		9	23.5	106
<i>Heterolocha gouldi</i> (Huia Bird)		2	19	21
<i>Strepera</i> , whole genus		9	28	98
<i>S. anaphonensis</i> (Grey Crow-Shrike) .		2	15	21
<i>S. graculina</i> (Pied " ") .		6	34	98
<i>S. fuliginosa</i> (Sooty " ") .		1	15	15
<i>Gymnorhina leuconota</i> (White-backed Piping Crow).		26	42	120
<i>G. tibicen</i> (Black-backed " ")		6	40	102
<i>Cracticus destructor</i> (Long-billed Butcher Crow).		5	39	133
<i>C. picatus</i> (Pied " ")		1	57	57
ALAUDIDÆ.				
<i>Aldaia</i> , whole genus		18	26	97
<i>A. arborea</i> (Wood-lark)		5	26	44
<i>A. arvensis</i> (Sky-lark)		3	33	55

ALAUDIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Alauda calivox</i> (Sweet-voiced Lark) ...	1	13	13
<i>A. crassirostris</i> (Thick-billed „) ...	1	24	24
<i>A. cristata</i> (Crested „) ...	7	15	86
<i>A. gulgula</i> (Indian Sky-lark) ...	1	97	97
<i>Calandrella boetica</i> (Andalusian Short- toed Lark).	7	14	19
<i>C. brachydactyla</i> (Short-toed Lark) ...	2	28	47
<i>Mirafra affinis</i> (Meadow Bush-Lark) .	1	14	14
<i>M. cantillans</i> (Pale Indian „ „) .	1	1·5	2
<i>Melanocorypha</i> , whole genus	20	11·5	81
<i>M. calandra</i> (Calandra Lark)	10	14·6	81
<i>M. mongolica</i> (Chinese „)	2	17	32
<i>M. yeltoniensis</i> (Black „)	8	6·5	14
<i>Rhamphocorys clotbeyi</i> (Clotbey's Lark).	3	13	19
<i>Pyrrhuloxia verticalis</i> (White-headed Bullfinch Lark).	6	16	35
<i>Otocorys alpestris</i> (Shore Lark)	12	25·6	61
<i>O. bilopha</i> (Algerian „ „)	2	9·5	10
PITTIDÆ.			
<i>Pitta bengalensis</i> (Bengal Pitta)	1	22·5	24
<i>P. strepitans</i> (Noisy „)	4	11	29
TYRANNIDÆ.			
<i>Machetornis rixosa</i> (Short-winged Tyrant).	2	45·5	76
<i>Tenioptera nengeta</i> (Pepoaza „)	1	5	5
<i>Tyrannus melancholicus</i> (Melancholy Tyrant).	1	67	67
<i>T. pipiri</i> (American King-bird)	1	12	12
<i>Pitangus sulphuratus</i> (Sulphury Tyrant).	21	34	104
<i>Milvulus tyrannus</i> (Fork-tailed „) .	1	38	38
COTINGIDÆ.			
<i>Chasmorhynchus niveus</i> (Carunculated Chatterer).	1	53	53
<i>C. nudicollis</i> (Naked-throated Bell- bird).	18	21	49
<i>Cotinga cincta</i> (Banded Cotinga)	2	31	57
<i>Rupicola crocea</i> (Cock of the Rock) ...	8	8·5	20
DENDROCOLAPTIDÆ.			
<i>Furnarius rufus</i> (Red Oven-bird). ...	2	5·5	7
MENURIDÆ.			
<i>Menura superba</i> (Lyre-bird)	2	57·5	107

Summary of Passeres.

The first general question that requires consideration is the value of the data on which this summary is based. Passerine birds, except to those who pay special attention to them as pets, are relatively little individualized, and in a large collection it may well be that the history of one individual has been assigned by mistake to another individual. I cannot doubt that such mistakes have sometimes occurred, but I do not think that they have had much effect on the figures. The bias they would give would tend on the whole to lower the figures, for where there was a doubt as to a dead individual in the Keeper's mind, I find that he was disposed to assume that it was the oldest example. Moreover, if the figures be run through in detail, it will be found that very often high records occur in cases where the number of examples was so few that confusion of individuals cannot have taken place, whilst the period of 33 years covered is so long in proportion to the numbers in most cases, that probably this source of error is on the whole insignificant.

Mr. J. H. Gurney's remarkable paper* has already made plain that birds attain considerable ages, and the figures of maximum duration that I am able to record are in no case improbable. It is to be remembered that probably the vast majority of Passerines are received at the Gardens in an adult condition, that the age of an adult bird cannot be determined from inspection, and therefore the maximum durations recorded are in all cases below, and may be much below the potential longevity. Mr. Gurney gives the following as the oldest Passerines of which he had been able to obtain information: Raven 69 years, *Gymnorhina tibicen*, 26 years, Nightingale, 25 years, Skylark 24, Goldfinch 23, Grosbeak 21, Canary 20, Bullfinch 19, Weaver-bird 9; and he sets down 20 to 24 years as the possible limit of most Passerines in captivity. Amongst the Garden records, I may select the following:—Grey Struthidea, nearly 19 years, Paradise Whydah Bird, over 16 years, Diuca Finch, nearly 16 years, Glossy Starling and American Robin, about 13 years, Bay Cowbird, over 12 years, an Indian Crow over 11 years, a Bulbul 11 years, a Great Titmouse 9 years, a Lyre-bird, nearly 9 years. Mr. W. Chamberlain, F.Z.S., informs me that he bought an adult Cardinal (*Paroaria cucullata*) in 1874; that in 1896 it showed signs of age, chiefly difficulty with the autumn moult, and thickening of the scales of the legs; that it died in 1899, having lived in a cage for 25 years 4 months. It must be noticed that if size be taken into consideration, the ages bear no relation to the relative sizes of the birds which attained to them, and moreover that Passeres as a whole, in comparison with their size, live to much greater ages than is the case with mammals. This is entirely in accordance with the views of Metchnikoff, for Passerine birds in every case have the hind-gut

* "The Comparative Ages to which Birds live," Ibis, 1899, p. 19.

and cæca very small in proportion to the total length and capacity of the alimentary canal. They digest rapidly, void their excreta at frequent intervals, and have very little opportunity for intestinal putrefaction.

With regard to viability, the record of Passerines is on the whole much better than in the case of mammals; that is to say, the maximum duration is frequently high and is much more nearly approached by the average duration. There are some notable exceptions. First, it is most striking that common British birds, like common British mammals, have very bad lives in captivity. I am inclined to put this down to the same kind of reasons. In the first place, it must frequently happen that birds are damaged by capture, or that many weak examples are taken, and these find their way quickly to the Gardens, there to die; whereas in the case of birds captured in remote regions, the deaths take place more frequently before arrival, and a selection of the hardier individuals is thus made automatically. The case would be more striking if I had included in the averages, the considerable number of birds that died without living for a month at the Gardens, a number relatively much greater in the case of common European and British forms. It seems, moreover, highly probable, that wild birds in this thickly populated country have survived in proportion to their development of a repulsion to the vicinity of man, a repulsion which only a small proportion of them, and that only gradually, can overcome in captivity. It is most remarkable how the average duration of such kinds as English Thrushes, Whinchats, Redstarts, Wheatears, Warblers, Tits, Nuthatches, Pipits, Shrikes, Linnets, Finches, Buntings, is from 12 months to 1 or 2 months, whilst that of their nearest foreign allies may be many times greater.

The viability, as shown by the average duration, has no constant relation to size. On the whole, soft-billed birds, such as the Tanagers, fed chiefly on fruit and prepared food, have been less successful than Finches and Weavers, and insectivorous birds have done less well than seed- and flesh-eaters. Nor is there any striking result to be obtained from consideration of the quarters assigned, for the vast majority of these Passerine birds have been kept under similar conditions. The Western Aviary, with open-air flights and heated retreats, has been their headquarters, although some of the small Finches, Tanagers, and Weaver Birds have been in cages in the Parrot House. The evidence points to Passerine birds having a good viability and a potential longevity, even in the case of the smallest, reaching well over twenty years. Although success has been greater than in the case of many mammals, I think that this is to be expected from the constitutions of these two sets of creatures, and that in proportion to their viability, the success in the case of Passerines is still far short of what might be achieved. Much has already been done to improve the access to air in the case of all the Passeres.

Capt. Flower's highest records are a Paradise Whydah Bird,

still alive after 9 years' duration; an Amaduvade Finch after 7 years, a Black-headed Chestnut-Finch after 9 years, a Java Sparrow of over 10 years' duration, and a Red-crested Cardinal of over 8 years' duration. It is noteworthy that these figures are comparable with my records and relate to species or genera which have had long-lived examples here. Actually our records are higher, but the number of individuals amongst which they occurred is greater.

PICARIDÆ.

CAPRIMULGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Caprimulgus europæus</i> (Nightjar).....	4	4	7

I have omitted a number of cases that lived for less than a month, but this is only another instance of failure with common European birds.

PICIDÆ.

<i>Dendrocopos major</i> (Greater Spotted Woodpecker).	16	9·8	33
<i>Centurus tricolor</i> (Banded „).	1	14	14
<i>Melanerpes erythrocephalum</i> (Red-headed Woodpecker).	1	2	2
<i>Leuconerpes candidus</i> (White-headed Woodpecker).	2	12	16
<i>Gecinus viridis</i> (Green Woodpecker)...	9	0	0
<i>Colaptes auratus</i> (Golden-winged Woodpecker).	8	23	54
<i>Lynx torquilla</i> (Wryneck)	5	0	0

Amongst the Woodpeckers and Wrynecks there is again complete failure with British birds, whilst the other figures would appear to show a low viability for the birds of this group, appearing both in the average and maximum durations.

COLIIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Colius</i> , whole genus	14	35	91
<i>C. capensis</i> (Cape Coly)	10	34·4	91
<i>C. castanotus</i> (Chestnut-backed Coly)...	2	8·5	9
<i>C. erythromelon</i> (Red-cheeked „)...	1	66	66
<i>C. nigricollis</i> (Black-necked „)...	1	65	65

These small, chiefly frugivorous birds, have in proportion to their size a good maximum and average duration, and must be inferred to have a good viability. It is interesting to note that the whole length of the intestines is remarkably short, although capacious, and there can be little opportunity for intestinal putrefaction. In the period under consideration the Colies were kept in the Parrot House, without access to open air.

ALCEDINIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Alcedo ispida</i> (Kingfisher)	27	4	24
<i>Halcyon</i> , whole genus	10	23	44
<i>H. chloris</i> (Green-headed Kingfisher) .	1	28	28
<i>H. sanctus</i> (Sacred ") .	5	17	32
<i>H. smyrnensis</i> (White-breasted Kingfisher)	1	26	26
<i>H. vagans</i> (New Zealand ")	3	30	44
<i>Dacelo</i> , whole genus	54	25.5	84
<i>D. cervina</i> (Buff Laughing Kingfisher).	2	28	34
<i>D. gigantea</i> (" ") .	51	25	84
<i>D. leachi</i> (Leach's " ") .	1	58	58

In the usual fashion, the failure with the Common Kingfisher has been very great. The other Kingfishers, in proportion to their size, show poor maximum and average durations, and these birds must be regarded as of relatively low viability. Although there are no cæca, the hind-gut is relatively long and capacious. Mr. Gurney cites, from the Rotterdam Gardens, an instance of a Laughing Kingfisher having lived for 11 years. Our highest regard is 7 years. In the period in question these birds have been kept in the Western Aviary, with heated interior but access to open air.

BUCEROTIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Bucorvus abyssinicus</i> (Ground Hornbill)	7	32	146
<i>B. cafer</i> (South African " ")	1	64	64
<i>Buceros lunatus</i> (Lunated Hornbill) ...	1	77	77
<i>B. rhinoceros</i> (Rhinoceros " ") ...	6	24	75
<i>Dichoceros bicornis</i> (Concave-casqued Hornbill)	10	56	167
<i>Anthraceros</i> , whole genus	9	24	51
<i>A. coronatus</i> (Crowned Hornbill).....	4	25	48
<i>A. malayanus</i> (White-billed Hornbill) .	1	10	10
<i>A. malabaricus</i> (Indian Pied " ") .	4	26	51
<i>Cranorrhinus corrugatus</i> (Wrinkled- billed Hornbill)	1	1	1
<i>Aceros nepalensis</i> (Nepalese " ")	2	5.5	10
<i>Ceratogymna elata</i> (Elate " ")	5	48	138
<i>Sphagolobus atratus</i> (Black " ")	5	40	121
<i>Bycanistes subcylindricus</i> (Subcylindric Hornbill).	2	59	94
<i>Rhytidoceros plicatus</i> (Plicated " ")	6	14.5	33
+ <i>undulatus</i> .			
<i>Toccus erythrorhynchus</i> (Red-billed " ")	4	33	61
<i>T. melanoleucus</i> (Black and White " ")	2	47	58

The Hornbills are omnivorous, rather large birds, and the record of maximum duration of 14 years for a Concave-casqued Hornbill

is by no means unexpectedly high. The relation of average duration to maximum duration varies but is on the whole good, showing a fairly high viability. These birds have been kept for the most part in a large aviary with heated retreats but access to the outer air.

UPUPIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Upupa epops</i> (Hoopoe)	7	17	29

The maximum and average durations show low viability.

MOMOTIDÆ.

<i>Momotus brasiliensis</i> (Brazilian Motmot)	1	74	74
<i>M. subrufescens</i> (Cartagenian „)	2	98	121

The numbers of individuals are very small but would appear to show a high viability for these omnivorous birds, which have been kept in a heated aviary with open-air flight-cages.

MEROPIDÆ.

<i>Merops apiaster</i> (Common Bee-eater) ...	2	12	13
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The very poor success with Bee-eaters is no doubt associated with the difficulty of feeding them.

CORACIIDÆ.

<i>Coracias affinis</i> (Allied Roller).....	1	21	21
<i>C. garrulus</i> (Common „).....	6	6.5	10

The difficulty with these omnivorous but largely insectivorous birds is probably the provision of suitable food.

PODARGIDÆ.

<i>Podargus cuvieri</i> (Cuvier's Podargus)...	4	12	32
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There seems no reason except low viability to account for the absence of success with this hardy-looking omnivorous bird.

STEATORNITHIDÆ.

<i>Steatornis caripensis</i> (Oil-bird)	1	1	1
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No just inference can be drawn from a single example.

RHAMPHASTIDÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Rhamphastos</i> , whole genus.....	59	35	143
<i>R. ariel</i> (Ariel Toucan)	27	24	101
<i>R. brevicarinatus</i> (Short-billed Toucan)	2	91	108
<i>R. carinatus</i> (Sulphur-breasted „)	7	26	58
<i>R. cuvieri</i> (Cuvier's „)	2	5	8
<i>R. dicolorus</i> (Green-billed „)	5	54	143

RHAMPHASTIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Rhamphastos erythrorhynchus</i> (Red-billed Toucan)	3	20	35
<i>R. tocard</i> (Doubtful Toucan)	2	67	91
<i>R. toco</i> (Toco Toucan)	9	44	93
<i>R. vitellinus</i> (Sulphur-and-white-breasted Toucan)	2	96·5	105
<i>Pteroglossus</i> , whole genus	20	29	87
<i>P. inscriptus</i> (Lettered Aracari)	5	20	30
<i>P. torquatus</i> (Banded „)	6	35	71
<i>P. wiedi</i> (Maximilian's „)	9	32	87
<i>Selenidera maculirostris</i> (Spot-billed Toucanet).	2	20	25

The Toucans and Aracaris are fruit-eating but partly omnivorous and flesh-eating birds, with simple intestines, the hind-gut being relatively short and not very capacious. Their viability as shown by maximum and average durations is relatively good. In the period in question they were kept in large cages in a warmed house, without access to the open air.

CAPITONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Megalæma</i> , whole genus	11	40	122
<i>M. asiatica</i> (Blue-cheeked Barbet) ...	6	42	104
<i>M. hodgsoni</i> (Hodgson's „) ...	1	4	4
<i>M. virens</i> (Great „) ...	4	46	122

The Barbets have an almost omnivorous diet and have short intestines, the hind-gut being relatively short and uncapacious. Their viability as shown by maximum and average durations is good, and in the period covered they were kept in cages in a warmed house without access to the open air.

CUCULIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cuculus canorus</i> (Cuckoo)	21	7	38
<i>Eudynamis orientalis</i> (Black Cuckoo)	5	19	41
<i>E. taitensis</i> (Long-tailed „)	1	3	3
<i>Centropus</i> , whole genus	6	20·5	37
<i>C. phasianus</i> (Pheasant Coucal)	1	19	19
<i>C. rufigenmis</i> (Indian „)	3	22	37
<i>C. senegalensis</i> (Senegal „)	2	18·5	19
<i>Crotophaga ani</i> (Ani)	5	6	26
<i>Guira piririgua</i> (Guira Cuckoo)	23	25	55

The Cuckoos are insectivorous and omnivorous birds with relatively capacious hind-guts. Their viability as shown by the maximum and average durations is low, but as is usual the failure has been most complete in the case of the Common Cuckoo. These birds have been kept under different conditions, sometimes with, and sometimes without, access to open air.

MUSOPHAGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Turacus</i> , whole genus	53	17·8	93
<i>T. buffoni</i> (Buffon's Touracou)	5	13	20
<i>T. corythaix</i> (White-crested Touracou). ..	9	28	93
<i>T. livingstoni</i> (Livingstone's ") ..	2	11	14
<i>T. macrorhynchus</i> (Great-billed ") ..	4	19	33
<i>T. persus</i> (Senegal ") ..	32	15	60
<i>T. schalowi</i> (Benguela ") ..	1	37	37
<i>Gallirex chlorochlamys</i> (Green-necked Touracou). ..	5	24	45
<i>G. porphyreolopha</i> (Purple-crested Touracou). ..	1	19	19
<i>Musophaga violacea</i> (Violaceous Plantain-eater). ..	7	17	44

The Touracous and Plantain-eaters are frugivorous and omnivorous birds with relatively simple intestines, the hind-gut being reduced. Their viability, as shown by maximum and average durations, is not good but surpasses that of the Cuckoos. They have been kept under varying conditions, always with artificial heat, but in some cases with access to the open air.

Summary of Picariæ.

Picarian birds form a heterogeneous group, united by no certain or close bands of affinity, and it is not surprising that their relative viabilities and longevities do not correspond with their gradations of size in any close fashion, although there is evidence of such a general relation. The maximum duration recorded is nearly 14 years for a Hornbill; then come a Toucan with nearly 12 years, a Motmot and Barbet with 10 years, a Touracou with nearly 8 years, and a Kingfisher with 7 years. The conditions under which these birds were kept during the period covered, have not differed much. In the vast majority of cases they were kept in houses or aviaries with artificial heat, but in some instances there was access, at least occasionally, to open-air flight-cages. I am unable, however, to draw any clear inference with regard to the effect of the mode of housing from the facts at my disposal. The very marked differences in viability exhibited, I think, must depend largely on real constitutional differences between the different suborders. The diet of the whole set tends to be mixed, with a strong leaning towards carnivorous or insectivorous character. The character of the alimentary tract varies considerably within the assemblage, and I think a marked correlation can be traced between the kind of gut and the viability. The Caprimulgidæ, Meropidæ, Coraciidæ, and Cuculidæ have all relatively capacious hind-guts and cæca, and in all these the average duration is low, generally under a year, whilst the maximum duration is never high. The Musophagidæ are generally

regarded as being closely allied to the Cuckoos; they have no cæca and a relatively uncapacious hind-gut, and their average duration is considerably over a year, whilst examples have lived over 7 years. The Ūpupidæ have no cæca but a relatively capacious hind-gut, and have a low viability. The Picidæ and Alcedinidæ have no cæca; the hind-gut of the Woodpeckers is certainly not specially capacious, and they must be regarded as exceptions to the generalization; the Kingfishers are rather better in viability, but in the family as a whole it is not good. On the other hand, the Musophagidæ, as I have already mentioned, the Momotidæ, the Coliudæ, the Capitonidæ, the Rhamphastidæ, and Bucerotidæ are all devoid of functional cæca, have relatively short and uncapacious hind-guts, and show amongst Picarian birds the highest average and maximum durations. The group appears to furnish considerable evidence for Metchnikoff's generalization as to the relation between long duration of life and the absence of opportunity for intestinal putrefaction.

It is interesting to note that Capt. Flower's only high Picarian record, that of a Coly still alive after 5 years' duration, is in my records surpassed by three different species of the same genus.

STRIGES.

STRIGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Strix flammea</i> (Barn Owl)	67	17.4	60
<i>Phodilus badius</i> (Bay Wood Owl)	1	50	50

ASIONIDÆ.

<i>Asio</i> , whole genus	77	10	30
<i>A. brachyotus</i> (Short-eared Owl)	22	11	30
<i>A. mexicanus</i> (Mexican Eared Owl) ...	2	15	15
<i>A. otus</i> (Long-eared Owl)	53	4	26
<i>Syrnium</i> , whole genus	71	21	134
<i>S. aluco</i> (Tawny Owl)	60	18	47
<i>S. indranee</i> (Indranee „)	4	55	134
<i>S. nebulosum</i> (Barred „)	1	63	63
<i>S. nuchale</i> (Sharp's Wood-Owl)	2	20	28
<i>S. sinense</i> (Pagoda Owl)	1	50	50
<i>S. personata</i> (Spectacled „)	1	12	12
<i>S. uralense</i> (Ural „)	1	2	3
<i>S. woodfordi</i> (Woodford's „)	1	8	8
<i>Bubo</i> , whole genus	88	32	111
<i>B. ascalaphus</i> (Savigny's Eagle-Owl) ...	1	34	34
<i>B. bengalensis</i> (Bengal „) ...	3	32	64
<i>B. blakistoni</i> (Blakiston's „) ...	2	16	23
<i>B. coromandus</i> (Coromandel „) ...	1	29	29
<i>B. lacteus</i> (Milky „) ...	2	58	99
<i>B. maculosus</i> (Spotted „) ...	17	27	59
<i>B. magellanicus</i> (Magellanic „) ...	1	7	7
<i>B. maximus</i> (Great „) ...	38	28	81

ASIONIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Bubo nepalensis</i> (Nepal Eagle-Owl)...	1	108	108
<i>B. orientalis</i> (Oriental ")...	1	83	83
<i>B. poensis</i> (Fraser's ")...	3	45	107
<i>B. virginianus</i> (Virginian ")...	18	34.8	111
<i>Ketupa ceylonensis</i> (Ceylonese Fishing-Owl).	4	10	26
<i>K. javanensis</i> (Javanese Fishing-Owl).	5	37	51
<i>Scops</i> , whole genus	17	8.6	45
<i>S. asio</i> (American Scops Owl)	1	26	26
<i>S. giu</i> (Scops Owl)	10	4.4	9
<i>S. glabripes</i> (Smooth-footed Scops Owl)	1	45	45
<i>S. lempiji</i> (Horsfield's ")	1	1	1
<i>S. leucotis</i> (White-eared ")	3	10	16
<i>S. senegalensis</i> (Senegal ")	1	2	2
<i>Scotopelia peli</i> (Pel's Owl)	1	5	5
<i>Pulsatrix torquata</i> (Downy Owl)	10	40	87
<i>Sceloglaux albifacies</i> (White-faced Owl)	1	33	33
<i>Athene brama</i> (Spotted Owl)	2	9.5	17
<i>A. noctua</i> (Naked-footed Owlet)	14	13.5	34
<i>Ninox boobook</i> (Boobook Owl)	3	26	50
<i>N. novæ-seelandiæ</i> (New Zealand Owl)	1	17	17
<i>Spectyto cunicularia</i> (Burrowing ")	46	21	65
<i>Glaucidium passerinum</i> (Passerine ")	13	6.5	17
<i>G. phalænoides</i> (Brown " ")	1	6	6
<i>Nyctea scandiaca</i> (Snowy Owl)	9	22	75
<i>Surnia funerea</i> (American Hawk Owl)	1	5	5

Summary of Striges.

We know from Mr. J. H. Gurney's paper (*loc. cit.* p. 36) that the potential longevity of Owls is far in excess of the maximum durations recorded here. On excellent authority, that writer cites an Eagle-Owl of 68 years, a *Ketupa* of 39 years, and a Tawny Owl of 26 years. The longest record on my list is that of an Indranee Owl which lived for over 11 years in the Gardens, and at the present time there are alive a Milky Eagle-Owl which has been for 19 years and a Pel's Owl which has been for 12 years in the Gardens. Until comparatively recently the quarters assigned to the Owls at the Gardens were extremely bad; it was assumed that Owls required neither light nor space. They have now been given better accommodation, and it is interesting to state, that except the Barn Owls, all the Owls take the fullest opportunity of sunning themselves and spend the greater part of their time fully exposed. Although a good deal must be discounted as a direct reaction to unfavourable conditions, it is still clear that the viability of Owls is not good; not only are the maximum durations far below what we know to be the potential longevitys, but the average durations are in most cases extremely

low. Owls, as is well known, have an unusually capacious hind-gut with very large cæca.

It is interesting to notice that all Capt. Flower's records of Owls are relatively low, just over 3 years being the highest.

PSITTACI.

NESTORIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Nestor notabilis</i> (Mountain Ka-ka) ...	14	41	227

LORIIDÆ.

<i>Chalcopsittacus scintillatus</i> (Red-fronted Lory).	1	34	34
<i>Eos</i> , whole genus.....	13	46·7	220
<i>E. riciniata</i> (Violet-necked Lory).....	4	22·5	50
<i>E. reticulata</i> (Blue-streaked „).....	3	32	59
<i>E. rubra</i> (Red Lory)	5	83	220
<i>E. wallacei</i> (Wallace's Lory)	1	2	2
<i>Lorius</i> , whole genus	26	39·9	107
<i>L. domicella</i> (Purple-capped Lory)...	10	37·3	88
<i>L. flavo-palliatu</i> s (Yellow-backed „)... 4	4	30	60
<i>L. garrulus</i> (Chattering „)... 4	4	59	107
<i>L. lory</i> (Three-coloured „)... 7	7	35·6	105
<i>L. tibialis</i> (Blue-thighed „)... 1	1	53	53
<i>Trichoglossus</i> , whole genus.....	31	55	210
<i>T. cyanogrammus</i> (Green-naped Lorikeet).	1	77	77
<i>T. forsteni</i> (Forsten's Lorikeet).....	1	14	14
<i>T. hæmatodes</i> (Blue-faced „).....	5	87	148
<i>T. mitchelli</i> (Mitchell's „).....	1	137	137
<i>T. novæ-hollandiæ</i> (Swainson's Lorikeet)	14	51·8	210
<i>T. ornatus</i> (Ornamental „) 7	7	38	84
<i>T. rubritorques</i> (Blue-bellied „) 2	2	20·5	22
<i>Psittentulus chlorolepidotus</i> (Scaly-breasted Lorikeet).	6	24	59
<i>Glossopsittacus concinnus</i> (Musky Lorikeet).	11	20·7	60

CACATUIDÆ.

<i>Microglossus aterrimus</i> (Great Black Cockatoo).	3	59·6	96
<i>Calyptorhynchus banksi</i> (Banksian Cockatoo).	3	221	310
<i>C. funereus</i> (Funereal Cockatoo)	2	44·5	87
<i>Callocephalon galeatum</i> (Ganga Cockatoo)	1	85	85
<i>Cacatua</i> , whole genus.....	84	55	229
<i>C. alba</i> (Greater White-crested Cockatoo).	5	66	92
<i>C. citrina</i> (Citron-crested „) 3	3	142	183
<i>C. ducorpsi</i> (Ducorps's „) 3	3	36	67

CACATUIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Cacatua galerita</i> (Greater Sulphur-crested Cockatoo).	8	49	113
<i>C. goffini</i> (Goffin's Cockatoo).	5	66.8	182
<i>C. gymnopsis</i> (Bare-eyed ").	2	113.5	131
<i>C. hæmaturophygia</i> (Red-vented ").	3	56	107
<i>C. leadbeateri</i> (Leadbeater's ").	17	40	98
<i>C. moluccensis</i> (Rose-crested ").	10	49.5	229
<i>C. ophthalmica</i> (Blue-eyed ").	5	70	112
<i>C. roseicapilla</i> (Roseate ").	10	12.4	41
<i>C. sanguinea</i> (Blood-stained ").	1	204	204
<i>C. sulphurea</i> (Lesser Sulphur-crested Cockatoo).	8	46	117
<i>C. triton</i> (Triton Cockatoo)	4	118	209
<i>Licmetis nasica</i> (Slender-billed Cockatoo)	5	58	95
<i>L. pastinator</i> (Western " ")	4	100	153
<i>Calopsittacus nova-hollandiæ</i> (Cockateel)	61	33	136

PSITTACIDÆ.

<i>Anodorhynchus</i> , whole genus.....	8	111	276
<i>A. glaucus</i> (Glaucous Macaw)	1	107	107
<i>A. hyacinthinus</i> (Hyacinthine Macaw)	4	95	117
<i>A. leari</i> (Lear's Macaw)	3	134	276
<i>Cyanopsittacus spixi</i> (Spix's Macaw) .	2	63.5	65
<i>Ara</i> , whole genus	49	57.5	199
<i>A. ambigua</i> (Ambiguous Macaw)...	2	147	199
<i>A. ararauna</i> (Blue-and-Yellow ")...	16	46	170
<i>A. chloroptera</i> (Red-and-Yellow ")...	9	66	191
<i>A. hahni</i> (Hahn's ")...	2	26	45
<i>A. macao</i> (Red-and-Blue ")...	9	60	177
<i>A. maracana</i> (Illiger's ")...	7	41	91
<i>A. militaris</i> (Military ")...	2	56	108
<i>A. nobilis</i> (Noble ")...	1	172	172
<i>A. severa</i> (Severe ")...	1	21	21
<i>Conurus</i> , whole genus	90	56	248
<i>C. acuticaudatus</i> (Sharp-tailed Conure)	1	1	1
<i>C. ceruginosus</i> (Brown-throated ")	24	40	144
<i>C. aureus</i> (Golden ")	8	76	153
<i>C. auricapillus</i> (Golden-headed ")	4	49	139
<i>C. aztec</i> (Aztec ")	2	18.5	21
<i>C. cactorum</i> (Cactus ")	2	32	54
<i>C. canicularis</i> (Petz's ")	4	32	44
<i>C. guarouba</i> (Golden ")	2	111.5	129
<i>C. hæmorrhous</i> (Blue-crowned ")	8	107	248
<i>C. holochlorus</i> (Mexican ")	1	92	92
<i>C. jendayi</i> (Yellow-headed ")	12	51	171
<i>C. nanday</i> (Black-headed ")	9	71.5	189
<i>C. ocularis</i> (Eyed ")	1	1	1
<i>C. chloropterus</i> (Green-winged ")	5	53	128

PSITTACIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Conurus rubritorquis</i> (Red-collared Conure)	1	19	19
<i>C. rubrolarvatus</i> (Red-masked ")	1	7	7
<i>C. solstitialis</i> (Yellow ")	4	42	74
<i>C. wagleri</i> (Wagler's ")	1	144	144
<i>Conuropsis carolinensis</i> (Carolina ")	6	81	114
<i>Cyanolyseus patagonus</i> (Smaller Pata- gonian Conure).	10	36.7	65
<i>Henicognathus leptorhynchus</i> (Slight- billed Parrakeet).	1	184	184
<i>Microsittace ferruginea</i> (Chilian Conure)	1	36	36
<i>Pyrrhura</i> , whole genus	21	54	172
<i>P. cruentata</i> (Red-eared Conure)	5	22	44
<i>P. leucotis</i> (White-eared ")	9	51	112
<i>P. perlata</i> (Pearly ")	2	98	172
<i>P. vittata</i> (Red-bellied ")	5	73	120
<i>Myopsittacus monachus</i> (Grey-breasted Parrakeet).	15	40	124
<i>Bolborhynchus lineolatus</i> (Lineolated Parakeet).	4	34	48
<i>Psittacula passerina</i> (Passerine Parrot)	17	22	57
<i>Brotogerys</i> , whole genus	30	35	93
<i>B. chrysopterus</i> (Golden-winged Parrakeet)	1	57	57
<i>B. jugularis</i> (Tovi ")	5	34	65
<i>B. pyrrhopterus</i> (Orange-flanked ")	4	52	78
<i>B. tirica</i> (All-green ")	8	32	93
<i>B. tui</i> (Tui ")	9	30	46
<i>B. tuipara</i> (Golden-fronted ")	1	45	45
<i>B. virescens</i> (Yellow-winged ")	2	19	20
<i>Chrysotis</i> , whole genus	168	43	312
<i>C. æstiva</i> (Blue-fronted Amazon)	11	36	103
<i>C. agilis</i> (Active ")	3	3	7
<i>C. albifrons</i> (White-browed ")	10	18	74
<i>C. amazonica</i> (Orange-winged ")	9	55	228
<i>C. augusta</i> (August ")	2	35.5	70
<i>C. auripalliata</i> (Golden-naped ")	8	83	312
<i>C. autumnalis</i> (Yellow-cheeked ")	8	34	122
<i>C. bodini</i> (Bodinus' ")	2	83	153
<i>C. bouqueti</i> (Bouquet's ")	1	72	72
<i>C. brasiliensis</i> (Red-tailed ")	3	66	128
<i>C. dufresniana</i> (Dufresne's ")	2	20	35
<i>C. caymanensis</i> (Cayman ")	1	11	11
<i>C. collaria</i> (Red-throated ")	6	36	62
<i>C. farinosa</i> (Mealy ")	6	52	68
<i>C. festiva</i> (Festive ")	4	35	49
<i>C. finschi</i> (Finsch's ")	3	63	121
<i>C. guatemalæ</i> (Guatemalan ")	2	14	28
<i>C. guildingi</i> (Guilding's ")	8	41	69

PSITTACIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Chrysotis leucocephala</i> (White-fronted "Amazon)	8	32	85
<i>C. levaillanti</i> (Levaillant's ")	8	68	157
<i>C. mercenaria</i> (Mercenary ")	1	13	13
<i>C. ochrocephala</i> (Yellow-fronted ")	8	45	88
<i>C. ochroptera</i> (Yellow-shouldered ")	6	50	136
<i>C. panamanensis</i> (Yellow-billed ")	6	60	147
<i>C. prætrii</i> (Prêtre's ")	4	12	18
<i>C. rhodocorytha</i> (Red-topped ")	6	36·5	119
<i>C. salvini</i> (Salvin's ")	6	40	82
<i>C. ventralis</i> (Sallé's ")	4	42	95
<i>C. versicolor</i> (Blue-faced ")	2	25	37
<i>C. vinacea</i> (Vinaceous ")	3	34	60
<i>C. viridigena</i> (Green-cheeked ")	9	63·5	123
<i>C. vittata</i> (Red-fronted ")	3	48	95
<i>C. xantholora</i> (Yellow-lored ")	5	46	83
<i>Pachyurus brachyurus</i> (Short-tailed Parrot).	2	30·5	52
<i>Pionus</i> , whole genus	28	29	111
<i>P. chalcopterus</i> (Bronze-winged Parrot)	2	26	49
<i>P. fuscus</i> (Dusky ")	9	14·5	34
<i>P. maximiliani</i> (Maximilian's ")	3	69	111
<i>P. menstruus</i> (Red-vented ")	11	23·8	62
<i>P. senilis</i> (White-headed ")	1	11	11
<i>P. sordidus</i> (Sordid ")	2	73·5	76
<i>Deroptys accipitrinus</i> (Hawk-headed Caique).	9	49	125
<i>Pionopsittacus pileatus</i> (Red-capped Parrot).	2	1	1
<i>Caica</i> , whole genus.....	16	47	248
<i>C. leucogastra</i> (White-bellied Caique).	2	6·5	8
<i>C. melanocephala</i> (Black-headed ")	12	39	104
<i>C. xanthomera</i> (Yellow-thighed ")	2	130	248
<i>Pæocephalus</i> , whole genus	46	32	249
<i>P. fuscicapillus</i> (Brown-headed Parrot)	2	53·5	55
<i>P. fuscicollis</i> (Brown-necked ")	4	79	241
<i>P. gulielmi</i> (Jardine's ")	6	12	49
<i>P. meyeri</i> (Meyer's ")	8	45	249
<i>P. robustus</i> (Levaillant's ")	2	24	45
<i>P. rueppelli</i> (Rüppell's ")	6	3·8	16
<i>P. senegalus</i> (Senegal ")	18	30	187
<i>Psittacus erithacus</i> (Grey ")	22	13	57
<i>P. timneh</i> (Timneh ")	4	84	123
<i>Coracopsis</i> , whole genus.....	13	164·7	648
<i>C. barklyi</i> (Praslin Parrot).....	6	93	152
<i>C. nigra</i> (Lesser Vasa ").....	4	98	144
<i>C. vasa</i> (Greater " ").....	3	397	648
<i>Eclectus</i> , whole genus.....	35	31	119
<i>E. cardinalis</i> (Cardinal Eclectus)	1	38	38

PSITTACIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Eclectus pectoralis</i> (Red-sided Eclectus)	13	34	90
<i>E. roratus</i> (Grand ")	12	47	119
<i>E. westermanni</i> (Westerman's ")	9	4.6	15
<i>Tanygnathus</i> , whole genus	12	62	189
<i>T. luzonensis</i> (Blue-crowned Parrakeet)	3	19	37
<i>T. megalorhynchus</i> (Great-billed ")	1	154	154
<i>T. muelleri</i> (Mueller's ")	8	66	189
<i>Palæornis</i> , whole genus	96	41	250
<i>P. alexandri</i> (Alexandrian Parrakeet).	15	53	247
<i>P. caniceps</i> (Grey-headed ")	1	2	2
<i>P. cyanocephala</i> (Blossom-headed ")	11	56	97
<i>P. docilis</i> (Rose-ringed ")	8	43	157
<i>P. fasciata</i> (Banded ")	10	69.6	160
<i>P. longicauda</i> (Malaccan ")	7	12	26
<i>P. nicobarica</i> (Red-cheeked ")	1	3	3
<i>P. peristerodes</i> (Malabar ")	7	47	86
<i>P. rosa</i> (Rosy ")	6	15	30
<i>P. torquatus</i> (Ring-necked ")	30	34	250
<i>Polytelis</i> , whole genus	15	31	72
<i>P. alexandrae</i> (Princess of Wales' Parrakeet)	3	23	49
<i>P. barrabaudi</i> (Barrabaud's ")	4	53	72
<i>P. melanurus</i> (Black-tailed ")	8	23	40
<i>Ptilistes erythropterus</i> (Red-winged Parrakeet).	13	33	61
<i>Aprosmictus coccinopterus</i> (Smaller Red-winged Parrakeet).	1	162	162
<i>A. cyanopygius</i> (King ")	19	27.5	80
<i>Pyrrhulopsis</i> , whole genus	17	44	116
<i>P. personata</i> (Masked Parrakeet)	7	52	89
<i>P. splendens</i> (Shining ")	5	44	116
<i>P. tabuensis</i> (Tabuan ")	5	31	113
<i>Psittinus incertus</i> (Blue-rumped Parrakeet).	1	20	20
<i>Agapornis</i> , whole genus	68	23	97
<i>A. cana</i> (Grey-headed Love-bird) ...	17	30	97
<i>A. pullaria</i> (West-African ") ...	38	16	56
<i>A. roseicollis</i> (Rosy-faced ") ...	13	22	40
<i>Loriculus</i> , whole genus	40	17	80
<i>L. chrysonotus</i> (Golden-backed Hanging-Parrakeet).	3	26	31
<i>L. galgulus</i> (Blue-crowned Hanging-Parrakeet).	21	17	80
<i>L. indicus</i> (Ceylonese Hanging-Parrakeet).	15	15	37
<i>L. pusillus</i> (Javan Hanging-Parrakeet)	1	9	9
<i>Platycercus</i> , whole genus	83	42.6	202
<i>P. adelaidæ</i> (Adelaide Broad-tail)	2	31	52

PSITTACIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Platycercus barnardi</i> (Barnard's Broad-tail)	5	86	202
<i>P. browni</i> (Brown's Broad-tail) ...	1	23	23
<i>P. elegans</i> (Pennant's " ") ...	17	29	143
<i>P. erythropeplus</i> (Red-mantled Broad-tail).	1	22	22
<i>P. eximius</i> (Rose-hill Broad-tail)	22	32.5	130
<i>P. flaveolus</i> (Yellow-rumped Broad-tail)	4	58.7	153
<i>P. flaviventris</i> (Yellow-bellied " ")	2	32.5	38
<i>P. icterotis</i> (Stanley Broad-tail).....	4	40	136
<i>P. pallidiceps</i> (Pale-headed Broad-tail)	9	40	128
<i>P. pileatus</i> (Pileated " ")	4	41	59
<i>P. semitorquatus</i> (Yellow-collared Broad-tail).	2	103	103
<i>P. zonarius</i> (Bower's " ")	10	55	133
<i>Psephotus</i> , whole genus	33	22.3	113
<i>P. chrysopterygius</i> (Golden-winged Parrakeet).	1	8	8
<i>P. haematonotus</i> (Blood-rumped Parrakeet).	15	23	67
<i>P. multicolor</i> (Many-coloured ").	7	20	113
<i>P. pulcherrimus</i> (Beautiful ").	10	16	57
<i>Neophema</i> , whole genus	53	22	75
<i>N. bourkii</i> (Bourke's Grass-Parrakeet)	6	36	62
<i>N. chrysogastra</i> (Orange-bellied Grass-Parrakeet).	4	23	55
<i>N. elegans</i> (Elegant Grass-Parrakeet)	12	21.5	68
<i>N. pulchella</i> (Turquoise Grass-Parrakeet).	28	20	75
<i>N. splendida</i> (Splendid Grass-Parrakeet)	2	12	18
<i>N. venusta</i> (Blue-banded Grass-Parrakeet).	1	11	11
<i>Cyanorhamphus</i> , whole genus	31	17	62
<i>C. auriceps</i> (Golden-headed Parrakeet)	5	19	54
<i>C. malherbi</i> (Alpine ")	4	14	32
<i>C. novæ-zealandiæ</i> (New Zealand Parrakeet).	16	15	43
<i>C. saisseti</i> (Saisset's ").	2	21	39
<i>C. unicolor</i> (Antipodes Island ").	4	26	62
<i>Nymphicus cornutus</i> (Horned ").	2	62.5	84
<i>N. uvæensis</i> (Uvæan ").	9	12.5	71
<i>Nanodes discolor</i> (Swift ").	8	23	43
<i>Melopsittacus undulatus</i> (Undulated Grass-Parrakeet).	109	23.6	111
<i>Geopsittacus occidentalis</i> (Western Ground-Parrakeet).	1	4	4
STRINGOPIDÆ.			
<i>Stringops habroptilus</i> (Night Parrot) .	4	8.2	16

Summary of Psittaci.

Popular repute and exact records agree in assigning a high potential longevity to Parrots. Metchnikoff (*op. cit.* p. 52) cites on the authority of Levaillant a Grey Parrot of 93 years, on that of Butler, a Sulphur-crested Cockatoo of 81 years, on that of Abrahams, an Amazon of 102 years, whilst he himself owned an Amazon which died at an age between 70 to 75 years. The figures in Mr. J. H. Gurney's list (*op. cit.* p. 36) are lower, the highest being a Blue Macaw of 64 years. The figures of maximum duration at the Gardens are very much lower in most cases. A Greater Vasa Parrot (already cited by Gurney) lived for 54 years. With regard to the others the figures of maximum duration are distributed nearly equally throughout the different groups of Psittaci; thus an Amazon and a Banksian Cockatoo reached about 26 years, a Macaw 23 years, a Conure, a *Pseoecephalus* Parrot and a small Parrakeet 20 years, a *Nestor* 19 years, a Lory 18 years, and a Lorikeet 17 years, whilst there are at present alive a Lesser Vasa Parrot which has lived in the Gardens for 26 years, and a Lorikeet of 17 years' duration.

I have no information as to the ages of the Parrots on their arrival at the Gardens, but as in an assemblage of 1480 birds, selected at random so far as age is concerned, there must have been many young birds, the maximum ages attained would appear to show that Parrots have not a high viability under the conditions to which they have been subjected, as otherwise there would have been a more frequent and closer approach of maximum duration to potential longevity. The records of average duration are not more favourable. The great majority of the birds had an average duration of somewhere between 2 and 4 years, a few such as the Lorikeets, Cockatoos, Conures, and Caiques were in most cases between 4 and 6 years, whilst the Macaws usually showed averages of over 6 years. I can see only the vaguest possible correlation between average and maximum durations and size, but on the whole there are more of the larger birds amongst the higher figures.

As we know that Psittaci have a high potential longevity, it is clear that either the conditions under which they are kept in captivity are markedly unfavourable, or that these birds have a low viability. In the period in question, the examples of this group were kept in a rather crowded house, well warmed in cold weather. A certain number of them were placed out of doors (chiefly Macaws and Cockatoos) in good weather, but were chained to perches. The vast majority of them were in relatively small cages, and never had access to open air, whilst none had the opportunity of flying. It is of course clear that exceptional individuals can do well without exercise, and it is highly probable that at least most of the birds cited as instances of high longevity, were kept in cages or on stands. But it is equally clear that such conditions, and in particular the absence of fresh air, are not favourable.

Parrots are typically vegetarian birds, although, as is well known, most of them do well if some animal material is added to their diet. The intestinal tract is long and unusually complex, but it is narrow in calibre, there are no cæca, and the greater portion appears to correspond with the small intestines, whilst there is little that is used as a reservoir for waste material, or that can be a probable seat of putrefaction. I cannot see that the indications point towards their low viability being the result of their constitution, and am disposed to attribute the relatively low maximum and average durations to unsatisfactory conditions. The Zoological Society has made experiments in recent years, in giving the larger parrots free exposure to the open air, without artificial heat. The experiment has not been of sufficiently long duration to test the effect on longevity; but even though the conditions are not specially favourable in the particular aviary, the general result appears to be good. I have no doubt that the ideal management is a combination of open-air flight cages with sheltered, and quite possibly warmed retreats.

Capt. Flower's best records are a Bare-eyed and a Slender-billed Cockatoo, still alive after 12 years' duration. As it was only in 1898 that he took charge of the Giza Gardens and began to make his records, about 12 years' duration was the maximum possible.

ACCIPITRES.

FALCONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pandion haliaëtus</i> (Osprey)	15	16	84
<i>Circus</i> , whole genus	23	15	43
<i>C. aeruginosus</i> (Marsh Harrier)	5	19	42
<i>C. cineraceus</i> (Montagu's ")	9	9	23
<i>C. cyaneus</i> (Hen ")	1	10	10
<i>C. gouldi</i> (Gould's ")	1	14	14
<i>C. macrurus</i> (Swainson's ")	1	43	43
<i>C. maurus</i> (Moor ")	6	16	39
<i>Buteo</i> , whole genus	95	25	225
<i>B. albicaudatus</i> (White-tailed Buzzard) ..	4	47	116
<i>B. auguralis</i> (Augura ") ..	2	8.5	13
<i>B. borealis</i> (Red-tailed ") ..	11	24	93
<i>B. desertorum</i> (African ") ..	10	37.6	225
<i>B. erythronotus</i> (Red-backed ") ..	8	18.5	38
<i>B. ferox</i> (Long-legged ") ..	4	16	20
<i>B. jackal</i> (Jackal ") ..	11	34	81
<i>B. pennsylvanicus</i> (Pennsylvanian ") ..	2	37.5	41
<i>B. poliosomus</i> (Patagonian ") ..	1	25	25
<i>B. vulgaris</i> (Common ") ..	42	19.5	72
<i>Archibuteo lagopus</i> (Rough-legged Buzzard) ..	22	14.5	36
<i>Pernis apivorus</i> (Honey Buzzard) ...	4	57	122
<i>P. ptilorhyncha</i> (Crested Honey Buzzard) ..	1	22	22

FALCONIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Haliastur indus</i> (Brahminy Kite) ...	1	62·5	110
<i>H. intermedius</i> (Javan Brahminy Kite) ...	2	116	116
<i>Asturina</i> , whole genus	6	8	23
<i>A. magnirostris</i> (Great-billed Buzzard Hawk).	1	11	11
<i>A. nattereri</i> (Natterer's Hawk)	3	10	23
<i>A. nitida</i> (Shining Buzzard Hawk) ...	2	2·5	4
<i>Urubitinga</i> , whole genus	5	30	49
<i>U. anthracina</i> (Ash-coloured Urubitinga).	1	49	49
<i>U. meridionalis</i> (Rusty Urubitinga)...	3	33	37
<i>U. zonura</i> (Banded-tailed Urubitinga)	1	2	2
<i>Buteogallus nigricollis</i> (Black-necked Buzzard).	1	8	8
<i>Leucopternis palliatus</i> (Mantled Buzzard).	2	9·5	14
<i>Geranouëtus melanolencus</i> (Chilian Sea-Eagle).	16	68·5	333
<i>Harpyhaliaëtus coronatus</i> (Crowned Harpy).	1	129	129
<i>Morphnus guianensis</i> (Guianan Crested Eagle).	2	20	23
<i>Thrasaëtus harpyia</i> (Harpy Eagle)...	7	18	48
<i>Helotarsus ecaudatus</i> (Bateleur „) ...	15	54	145
<i>Haliaëtus</i> , whole genus	60	35·5	122
<i>H. albicillus</i> (White-tailed Eagle).....	22	34	86
<i>H. leucocephalus</i> (White-headed Sea-Eagle).	15	36	122
<i>H. leucogaster</i> (White-bellied Sea-Eagle).	9	36	91
<i>H. leucoryphus</i> (Mace's Sea-Eagle) ...	1	1	1
<i>H. vocifer</i> (Vociferous „ „) ...	13	39	86
<i>Poliouëtus plumbeus</i> (Plumbeous Fish-Eagle.)	2	74	82
<i>Aquila</i> , whole genus	83	66·3	257
<i>A. adalberti</i> (Prince Adalbert's Eagle) .	2	90	136
<i>A. audax</i> (Wedge-tailed „) .	15	94·5	257
<i>A. chrysaëtus</i> (Golden „) .	39	35	170
<i>A. clanga</i> (Spotted „) .	2	38·5	65
<i>A. imperialis</i> (Imperial „) .	8	78	141
<i>A. nevioides</i> (Tawny „) .	12	56·5	150
<i>A. verreauxi</i> (Vulturine „) .	5	31	77
<i>Nisaëtus</i> , whole genus	13	36·6	152
<i>N. fasciatus</i> (Bonelli's Eagle)	8	28	66
<i>N. pennatus</i> (Booted „)	4	51	152
<i>N. spilogaster</i> (African Hawk-Eagle)...	1	46	46
<i>Spizaëtus</i> , whole genus	23	32·8	77
<i>S. bellicosus</i> (Martial Hawk-Eagle) ...	2	46	69

FALCONIDÆ (<i>cont.</i>).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Spizaetus caligatus</i> (Malayan Hawk-Eagle).	1	22	22
<i>S. ceylonensis</i> (Ceylonese " ")...	3	21	46
<i>S. coronatus</i> (Crowned " ")...	10	38·7	77
<i>S. nipalensis</i> (Spotted " ")...	3	29	45
<i>S. orientalis</i> (Japanese " ")...	1	21	21
<i>S. ornatus</i> (Ornamented " ")...	2	32	43
<i>S. tyrannus</i> (Tyrant " ")...	1	15	15
<i>Lophætus occipitalis</i> (Black-crested Eagle).	5	34	49
<i>Circætus gallicus</i> (Short-toed Eagle) .	13	15	40
<i>Dryotriorchis spectabilis</i> (Beautiful Wood-Hawk).	1	14	14
<i>Spilornis</i> , whole genus	4	18·5	45
<i>S. bacha</i> (Bacha Eagle)	2	8·5	9
<i>S. cheela</i> (Cheela " ")	1	12	12
<i>S. spilogaster</i> (Ceylonese Serpent-eater)	1	45	45
<i>Accipiter</i> , whole genus	11	1·6	4
<i>A. nisus</i> (Sparrow Hawk)	9	1·7	4
<i>A. pileatus</i> (Pileated " ")	1	1	1
<i>A. melanoleucus</i> (Black and White Hawk).	1	1	1
<i>Melierax</i> , whole genus	12	16·5	91
<i>M. monogrammicus</i> (One-streaked Hawk).	7	10	31
<i>M. musicus</i> (Chanting Hawk)	1	91	91
<i>M. polyzonus</i> (Many-zoned " ")	4	8·7	21
<i>Astur</i> , whole genus	35	16·3	150
<i>A. approximans</i> (Allied Goshawk) ...	4	58	150
<i>A. novæ-hollandiæ</i> (White " ") ...	4	38	75
<i>A. palumbarius</i> (Common " ") ...	22	7	22
<i>A. tachiro</i> (Tachiro " ") ...	4	6·5	9
<i>A. tibialis</i> (Gambian " ") ...	1	1	1
<i>Falco</i> , whole genus	108	18·5	117
<i>F. æsalon</i> (Merlin)	7	17·5	94
<i>F. biarmicus</i> (Bearded Falcon)	1	40	40
<i>F. concolor</i> (Ash-coloured " ")	2	25	43
<i>F. eleonoræ</i> (Eleonora " ")	1	4	4
<i>F. feldeggii</i> (Feldegg's " ")	1	28	28
<i>F. fusco-cærulescens</i> (Orange-thighed Falcon).	2	34	42
<i>F. lanarius</i> (Lanner Falcon)	14	35	117
<i>F. melanogenys</i> (Black-cheeked Falcon)	3	21	43
<i>F. peregrinus</i> (Peregrine Falcon)	61	15	89
<i>F. punicus</i> (Mediterranean Peregrine Falcon).	1	2	2
<i>F. sacer</i> (Saker Falcon)	3	23	39
<i>F. subbuteo</i> (Hobby)	12	9	40
<i>Hierofulco candicans</i> (Greenland Falcon)	2	32·5	51

FALCONIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Hierofalco islandus</i> (Iceland Falcon)...	6	33	93
<i>Hieracidea berigora</i> (Berigora Hawk) .	5	32	101
<i>Tinnunculus</i> , whole genus	81	15.8	151
<i>T. alaudarius</i> (Common Kestrel).....	45	17	76
<i>T. cenchris</i> (Lesser ").....	9	17	76
<i>T. cenchroides</i> (Nankeen ").....	2	7.5	13
<i>T. dominicensis</i> (Dominican ").....	13	13	63
<i>T. gracilis</i> (Slender ").....	2	12	15
<i>T. moluccensis</i> (Molucca ").....	1	10	10
<i>T. rupicolus</i> (S. African ").....	2	9	11
<i>T. sparverius</i> (American ").....	4	10.5	14
<i>T. vespertinus</i> (Red-footed ").....	3	71	151
<i>Hypotriorchis chicquera</i> (Red-headed Merlin).	1	5	5
<i>Milvus</i> , whole genus	30	68.5	191
<i>M. govinda</i> (Indian Kite).....	4	55	89
<i>M. migrans</i> (Black ").....	8	58	191
<i>M. ægyptius</i> (Egyptian ").....	12	65	165
<i>M. iclinus</i> (Common ").....	6	98	173
<i>Baza lophotes</i> (Crested Black Kite) ...	1	1	1
<i>Elanus cæruleus</i> (Black-shouldered Kite).	6	8	17
<i>Rostrhamus sociabilis</i> (Sociable Marsh- Hawk).	2	4	7
<i>Herpetotheres cachinnans</i> (Laughing Falcon).	2	10.5	12
<i>Milvago</i> , whole genus	26	65	168
<i>M. australis</i> (Forster's Milvago)...	5	21	48
<i>M. chimachima</i> (Chimachima ")...	5	74	129
<i>M. chimango</i> (Brown ")...	14	69	164
<i>M. megalopterus</i> (Long-winged ")...	2	113	168
<i>Polyborus brasiliensis</i> (Brazilian Caracara).	7	143	496
<i>Polyboroidestypicus</i> (Banded Gymnogere)	2	39	45

VULTURIDÆ.

<i>Vultur</i> , whole genus	19	94	284
<i>V. auricularis</i> (Sociable Vulture)	7	93	284
<i>V. calvus</i> (Pondicherry ")	3	69	68
<i>V. monachus</i> (Cinereous ")	8	115.5	183
<i>V. occipitalis</i> (Occipital ")	1	2	2
<i>Gyps</i> , whole genus	14	72	261
<i>G. bengalensis</i> (Bengal Vulture)	3	15	33
<i>G. fulvus</i> (Griffon ")	8	85.5	261
<i>G. kolbi</i> (Kolbe's ")	1	44	44
<i>G. rueppelli</i> (Rüppell's ")	2	116	168
<i>Neophron percnopterus</i> (Egyptian Vulture).	9	27	99

VULTURIDÆ (<i>cont.</i>).			No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Gypohierax angolensis</i>	(Angolan Vulture).		12	40	66
<i>Gypaëtus barbatus</i>	(European Bearded Vulture).		6	113	284
SERPENTARIIDÆ.					
<i>Serpentarius reptilivorus</i>	(Secretary Vulture).		26	12	59
CATHARTIDÆ.					
<i>Cathartes</i> , whole genus			23	22	70
<i>C. atratus</i>	(Black Vulture)		15	18	57
<i>C. aura</i>	(Turkey ")		7	30	70
<i>C. urubitinga</i>	(Yellow-headed Vulture).		1	8	8
<i>Sarcorhamphus aequatorialis</i>	(Brown Condor).		1	96	96
<i>S. gryphus</i>	(Condor)		6	155	403
<i>Gypagus papa</i>	(King Vulture)		18	20	87

Summary of Accipitres.

The potential longevity of Accipitrine birds is well known to be great, although, as in most other cases, well-authenticated records are considerably lower than the ages assigned by popular rumour. Metchnikoff (*op. cit.* p. 53) refers to a White-headed or Egyptian Vulture of 118 years, and a Golden Eagle of 104. Mr. J. H. Gurney's exact records (*loc. cit.* p. 37) range downwards from a Bateleur Eagle of 55 years and a Condor of 52. The maximum durations in my record are considerably lower; those over 20 years are a Caracara of over 41, a Condor of nearly 34, a Chilean Sea-Eagle of nearly 28, a Sociable and an Angolan Vulture which reached nearly 24, a Griffon of nearly 22 and a Wedge-tailed Eagle of more than 21 years; whilst there is at present alive, a Milvago that has been over 24 years in the Gardens. The average durations mostly under 2 years are of Ospreys, Harriers, Hawks, Falcons, Kestrels, Secretary Bird, and the American Vultures; those mostly between 2 and 4 years, are of Buzzards, Sea-Eagles, and the larger Hawk-Eagles; those mostly between 4 and 6 years are of the Chilean Sea-Eagles, Goshawks, and Kites; whilst the records above 6 years belong chiefly to Wedge-tailed Eagles, Imperial Eagles, the larger Vultures and the Condor. There is a rough relation between size and viability, and there is the usual very low viability of the common European forms. The conditions under which the birds of prey have been kept, in the period covered, cannot be said to have led to a favourable result. In the great majority of cases no artificial heat was provided, even in winter, and there was full access to open air, but especially in the case of the smaller birds, the quarters were small and dark, and there was no provision for exercise. If the records be compared with those of the Striges, it will be seen,

however, that both average and maximum durations are considerably better in the case of the diurnal birds of prey. No intelligent anatomist can now doubt that the two groups are far separate amongst birds, and one of the notable differences is in the structure of the alimentary tract. In all the Accipitrine birds, although the intestines are relatively long and arranged in a complex pattern, the hind-gut and caeca are extremely reduced, and the portion of the gut in which there is the greatest opportunity for intestinal putrefaction therefore has a relatively very small capacity.

Capt. Flower records only two Accipitrine birds—a Griffon Vulture and an Egyptian Vulture—that are still alive after 12 years' duration, the maximum possible in his records.

STEGANOPODES.

PELECANIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pelecanus</i> , whole genus	21	139	380
<i>P. conspicillatus</i> (Australian Pelican) .	2	285	380
<i>P. crispus</i> (Crested ") .	2	274.5	329
<i>P. fuscus</i> (Brown ") .	3	65	121
<i>P. manillensis</i> (Spot-billed ") .	2	54	65
<i>P. mitratus</i> (Mitred ") .	3	130	261
<i>P. onocrotalus</i> (White ") .	3	239	350
<i>P. rufescens</i> (Red-backed ") .	6	66	152

Mr. J. H. Gurney (*loc. cit.* p. 38) gives the records of six Pelicans ranging from 41 to 18 years, and the maximum durations given above, ranging downwards from nearly 32 years, are all remarkably high, whilst the average durations show that these birds are probably the most highly viable of all the birds and mammals usually kept in captivity. They were not provided with artificial heat, but throughout the day were exposed fully to the weather, whilst at night, and occasionally in very cold or foggy conditions, they were shut up in a small wooden shelter. As compared with other fish-eating birds, the alimentary tract is relatively short and simple, and the caeca and hind-gut are small (although not so reduced as in Accipitrine birds) and uncapacious.

Capt. Flower records one White Pelican still alive after 12 years.

FREGATIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Fregata aquila</i> (Great Frigate-bird) ...	5	45.6	91

It is most probable that only weak or injured examples of this oceanic bird usually find their way into captivity, and the records, I think, must be interpreted as showing a high viability. The intestinal tract is simpler than that of Pelicans, with the hind-gut and caeca more reduced. These birds have been kept in an aviary with warmed interior and open-air front cages.

PHALACROCORACIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sula</i> , whole genus	39	8·3	40
<i>S. bassanus</i> (Gannet)	27	6	19
<i>S. leucogastra</i> (Brown Gannet)	5	15	40
<i>S. piscator</i> (White ")	2	14	19
<i>S. serrator</i> (Australian ")	5	8·8	16
<i>Phalacrocorax</i> , whole genus	84	12	94
<i>P. brasilianus</i> (Brazilian Cormorant) ...	9	10·5	55
<i>P. africanus</i> (African ") ...	2	23·5	36
<i>P. carbo</i> (Common ") ...	53	10·5	52
<i>P. carunculatus</i> (Rough-faced ") ...	2	28	49
<i>P. graculus</i> (Shag)	15	10	44
<i>P. javanicus</i> (Javan Cormorant)	1	38	38
<i>P. lugubris</i> (Mournful ")	1	94	94
<i>P. varius</i> (Pied ")	1	1	1

Mr. J. H. Gurney (*loc. cit.* p. 38) quotes from H. O. Forbes the record of a Common Cormorant which lived for 23 years. The maximum durations on my list, ranging from nearly 8 years downwards, are very much lower, whilst the average durations of both Gannets and Cormorants seldom exceed one year. There is the usual remarkable failure with local species—a failure which would appear much greater if a considerable number of entries of birds that lived less than a month had not been excluded from the records. The intestinal tracts are of the fish-eating type—relatively large and of small calibre, but the hind-gut and cæca are very rudimentary, and there seems little opportunity for intestinal putrefaction.

PLOTIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Plotus</i> , whole genus	16	22	103
<i>Plotus ankinga</i> (American Darter)	12	18	53
<i>P. levaillanti</i> (Levaillant's ")	2	18	34
<i>P. melanogaster</i> (Indian ")	2	55·5	103

J. H. Gurney (*loc. cit.* p. 38) gives an instance of an American Darter of 12 years old; I do not know of any other records. The intestinal tract is similar to that of other Steganopodes, but although the cæca (or single cæcum) are vestigial, the hind-gut is relatively more capacious and larger. These birds were kept in a house (the Fish House) that was warmed in winter, and their average duration and maximum duration show no high viability.

Summary of Steganopodes.

Peleicans, Frigate-birds, Gannets, Cormorants and Darters, whether or no they form a coherent zoological group, differ very little in their requirements in captivity, and receive very much the same treatment. They appear to me to be a group of potentially

great longevity and viability, these, moreover, being fairly in proportion to size. The records of Phalacrocoracidae are much lowered by the number of European birds, which like most European animals have a very heavy death-rate in captivity.

HERODIONES.

ARDEIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Ardea</i> , whole genus	90	25	110
<i>A. agami</i> (Agami Heron) ...	1	5	5
<i>A. alba</i> (Great White ") ...	4	7.5	26
<i>A. atricollis</i> (Black-necked ") ...	1	24	24
<i>A. bubulcus</i> (Buff-backed ") ...	4	50	64
<i>A. candidissima</i> (Snowy ") ...	10	20	74
<i>A. cinerea</i> (Common ") ...	23	28	115
<i>A. cocoi</i> (Cocoi ") ...	4	42	93
<i>A. egretta</i> (Great American Egret) ...	16	31	100
<i>A. garzetta</i> (Little ") ...	4	35	98
<i>A. goliath</i> (Goliath Heron).....	1	35	35
<i>A. gularis</i> (Slaty ").....	7	19	72
<i>A. herodias</i> (Great American Heron).	1	31	31
<i>A. novæ-hollandiæ</i> (White-faced ").	2	13	17
<i>A. purpurea</i> (Purple ").	9	4.6	10
<i>A. ralloides</i> (Squacco ").	2	6.5	11
<i>A. sumatrana</i> (Typhon ").	1	69	69
<i>Butorides</i> , whole genus	9	14	53
<i>B. atricapillus</i> (Blue-capped Bittern) .	2	44.5	53
<i>B. cyanurus</i> (South American Little Bittern).	1	12	12
<i>B. virescens</i> (Green Bittern)	6	4	13
<i>Ardetta involucris</i> (Variegated Bittern).	3	23	40
<i>A. minuta</i> (Little Bittern).....	8	6	19
<i>Nycticorax</i> , whole genus.....	64	30	199
<i>N. caledonicus</i> (Nankeen Night Heron).	2	99	107
<i>N. gardeni</i> (Garden's Night Heron).	6	9	32
<i>N. griseus</i> (Common " ").	31	37	199
<i>N. violaceus</i> (Violaceous " ").	25	19.5	61
<i>Cancroma cochlearia</i> (Boat-bill).....	9	21	53
<i>Botaurus lentiginosus</i> (American Bittern).	1	8	8
<i>B. stellaris</i> (Bittern)	3	23	54
<i>Tigriosoma brasiliense</i> (Tiger Bittern).	6	48.5	162
<i>T. leucolophum</i> (White-crested " ").	7	20.5	33

J. H. Gurney (*loc. cit.* p. 38) gives somewhat doubtful records of 60 and 30 years, and a well authenticated record of 22 years for a Common Heron. A duration of over 16 years for a Night Heron is the best on my list. The average and maximum

durations show a rough correspondence with size; but the relations of average to maximum duration show rather a low viability for these birds. The intestinal tract is of the fish-eating type, relatively very large and of small calibre, but with vestigial cæca and with a reduced hind-gut. The conditions under which these birds have been kept differ; some were placed in open enclosures, others, especially in winter, in an aviary with warmed interior.

CICONIIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Ciconia</i> , whole genus	56	25	111
<i>C. alba</i> (White Stork)	34	26	74
<i>C. boyciana</i> (Boyce's ")	2	14·5	28
<i>C. nigra</i> (Black ")	20	20	111
<i>Dissura episcopus</i> (White-necked Stork).	12	30	64
<i>D. maguari</i> (Maguari Stork)	10	40	84
<i>Abdimia sphenorhyncha</i> (White- bellied Stork).	3	50	81
<i>Xenorhynchus australis</i> (Black-necked Stork).	11	18	68
<i>X. senegalensis</i> (Saddle-billed ") ..	4	26	59
<i>Mycteria americana</i> (American Jabiru).	8	34·5	65
<i>Leptoptilus</i> , whole genus	19	46·5	227
<i>L. argala</i> (Indian Adjutant)	5	77	227
<i>L. crumeniferus</i> (Marabou Stork) ...	9	47	117
<i>L. javanicus</i> (Javan Adjutant)	5	15	35
<i>Scopus umbretta</i> (Tufted Umbre) ...	5	24	43
<i>Tantalus loculator</i> (American Tantalus).	7	10·5	23
<i>Pseudotantalus ibis</i> (African ") ..	13	15	31
<i>P. leucocephalus</i> (Indian ") ..	7	11·5	23

Mr. J. H. Gurney (*loc. cit.* p. 38) cites well authenticated records of a Black Stork of 30 years and a Jabiru of 36 years. Nearly 19 years for an Adjutant is the highest on this list, whilst the average durations vary, roughly in proportion to size, from about 4 years to about 1 year. During part of the period in consideration, the larger tropical Storks were kept in the Antelope House, which was warmed in winter; towards the end of the period a new house was erected, in which there were heated compartments leading to open-air paddocks to which the birds were admitted at the discretion of the keepers—a discretion usually exercised with a strong bias in favour of heat as opposed to air. The intestinal tract is relatively long and of small calibre but the hind-gut and cæca are very reduced. There appears to be no good reason in the structure of these birds for the relatively low viability which appears in the records.

PLATALEIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Platalea alba</i> (African Spoonbill)	2	21	29
<i>P. leucorodia</i> (Spoonbill)	19	16·5	115
<i>Ajaja rosea</i> (Roseate Spoonbill).....	11	19	38
<i>Ibis</i> , whole genus	17	80	220
<i>I. æthiopicus</i> (Sacred Ibis).....	8	94	191
<i>I. bernieri</i> (Bernier's „).....	2	25	38
<i>I. melanocephalus</i> (Black-headed Ibis).	1	83	83
<i>I. strictipennis</i> (Australian Sacred „).	6	87	220
<i>Carphibis spinicollis</i> (Straw-necked Ibis).	4	109·8	300
<i>Nipponia temmincki</i> (Nippon „).	1	5	5
<i>Theristicus caudatus</i> (Black-faced „).	3	16	41
<i>T. melanopsis</i> (Grey „).	5	18	31
<i>Plegadis falcinellus</i> (Glossy „).	18	30·5	112
<i>P. guarauna</i> (White-faced „).	2	5	5
<i>Eudocimus</i> , whole genus.....	43	25·5	143
<i>E. albus</i> (White Ibis)	5	69·5	143
<i>E. longirostris</i> (Red-billed „)	2	8·5	12
<i>E. ruber</i> (Scarlet „)	36	20	90

Mr. J. H. Gurney (*loc. cit.* p. 38) records from our own Gardens a Sacred Ibis alive at 20 years old, and another bird of the same species from Rotterdam of 11 years. In the list given above there is a Straw-necked Ibis with a duration of 25 years, and an Australian Sacred Ibis of over 18 years, whilst there are a number of other high records. The figures of average duration are very varied, but in several cases they extend to a number of years, the low figures being chiefly birds of which there were very few examples.

In the period in question nearly all these birds had free access to the open air, but in some cases had shelter in a heated aviary in winter. Ibises have a simply disposed but rather long intestinal tract, with the cæca and the hind-gut much reduced. It must be inferred from the figures that they are birds of good viability in proportion to their size.

Summary of Herodiones.

Hérons, Storks, Spoonbills and Ibises form a coherent zoological group all chiefly carnivorous or piscivorous, with relatively long, narrow, intestinal tracts, the posterior region of which is reduced and uncapacious. Within the different groups there is a fair correspondence between duration and size, but this does not reach to the whole assemblage, as the Spoonbills and Ibises show a better viability than the Storks, whilst the Herons are lowest of all. I see no reason for assuming much difference (except perhaps in proportion to size) between the potential longevities of the three divisions, and must assume that the

conditions of captivity have pressed most heavily on the Herons. I have not sufficient information to point to any special unfavourable circumstance in the case of the Herons.

Capt. Flower records no example of the *Herodiones* still alive after 12 years.

ODONTOGLOSSÆ.

PHENICOPTERIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Phœnicopterus</i> , whole genus	23	82	273
<i>P. ignipalliatu</i> s (South American Flamingo).	5	42	105
<i>P. roseus</i> (European Flamingo)	9	163	273
<i>P. rubra</i> (Ruddy ,,)	9	21	147

I can find no published statements regarding the longevity of these large birds, and the maximum duration of nearly 23 years for a European Flamingo is therefore specially interesting. I know of no reason for the greater success of the European form. The distribution of individual durations with regard to the maximum durations shows that the deaths with low duration have nearly always taken place soon after arrival: if the birds of any of the three species survived two or three months, they lived years. These birds live on a mixed diet, in captivity taking a good deal of grain; the alimentary tract is relatively long and slender, but the posterior portion and the cæca are more capacious than in most birds. They have been kept with complete exposure to the open air in summer, whilst in winter, in the period to which the records refer, they were usually transferred to an aviary with open-air cages and heated retreats. Flamingoes have a high longevity and viability under such conditions.

PALAMEDEÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Chauna cristata</i> (Crested Screamer) ...	11	45·8	115
<i>C. derbiana</i> (Derbian ,,) ...	8	16·5	84
<i>Palamedea cornuta</i> (Horned ,,) ...	3	31·1	43

I am unaware of published records as to the longevity of Screamers. The maximum duration, over 9 years in the case of a Crested Screamer, is surpassed by two examples of the species, at present alive in the Gardens, after a duration of nearly 13 years. As in the case of the Flamingoes, the incidence of the mortality was especially heavy on new arrivals: if the birds lived a few months, they usually approached the maximum duration recorded. Screamers are large, bulky birds, with the alimentary tract of a primitive type, the hind-gut and cæca being relatively capacious. They have been kept under conditions relatively similar to those of the Flamingoes, and certainly in proportion to their size cannot be regarded as highly viable.

ANSERES.

CYGNINÆ.	No. of Indiv.	Aver. dur. in months.	Max dur. in months.
<i>Cygnus</i> , whole genus	88	33·5	177
<i>C. atratus</i> (Black Swan) ...	13	18	72
<i>C. buccinator</i> (Trumpeter ") ...	7	55	144
<i>C. bewicki</i> (Bewick's ") ...	7	53	114
<i>C. musicus</i> (Whooper ") ...	8	55·5	132
<i>C. olor</i> (Mute ") ...	12	41·5	177
<i>C. nigricollis</i> (Black-necked ") ...	41	24	141
<i>Coscoroba candida</i> (Coscoroba ") ...	7	36	103

Mr. J. H. Gurney has recorded (*loc. cit.* p. 39), on the authority of W. J. Broderip, a Mute Swan of 70 years; the highest figure on my list is not quite 15 years. The distribution of the individual durations about the average, shows that the heaviest mortality was in those examples which lived only a few months, and were either new arrivals, or cygnets; if individuals survived the early period of detention, they approached the maximum.

ANSERANATINÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Anseranas semipalmata</i> (Black and White Goose).	6	171·5	229

PLECTROPTERINÆ.

<i>Plectropterus</i> , whole genus	15	72	152
<i>P. gambensis</i> (Spur-winged Goose) ...	12	82	152
<i>P. niger</i> (Black " " ") ...	2	28·5	31
<i>P. rueppelli</i> (Rüppell's " " ") ...	1	36	36
<i>Cairina moschata</i> (Muscovy Duck) ...	23	9	93
<i>Sarcidiornis carunculata</i> (American Black-backed Goose).	5	33	117
<i>S. melanonota</i> (Black-backed Goose) ...	8	61	110
<i>Rhodonessa caryophyllacea</i> (Pin-headed Duck)	5	16	23
<i>Aex galericulata</i> (Mandarin ")	80	42	135
<i>Aex sponsa</i> (Summer ")	85	34	117

CEREOPSINÆ.

<i>Cereopsis novæ-hollandiæ</i> (Cereopsis Goose).	13	36	19
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ANSERINÆ.

<i>Chen</i> , whole genus	10	112·7	198
<i>C. hyperboreus</i> (Wavy Snow-Goose) ...	3	85	92
<i>C. caerulescens</i> (Blue " " ") ...	3	57	103
<i>C. nivalis</i> (Lesser " " ") ...	4	175	198
<i>Anser</i> , whole genus	41	71	289
<i>A. albifrons</i> (White-fronted Goose) ...	6	74	168
<i>A. brachyrhynchus</i> (Pink-footed Goose)	4	52	99
<i>A. cinereus</i> (Grey-Lag Goose)	12	41·5	126
<i>A. cygnoides</i> (Chinese ")	7	70	153

ANSERINÆ (cont.).		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Anser erythropus</i> (Little Goose).....		2	174	289
<i>A. indicus</i> (Bar-headed „).....		8	124	261
<i>A. segetum</i> (Bean „).....		2	26.5	49
<i>Bernicla</i> , whole genus		61	36.3	142
<i>B. brenta</i> (Brent Goose).....		32	17	66
<i>B. canadensis</i> (Canada „).....		14	44	111
<i>B. hutchinsi</i> (Hutchins' „).....		2	86	119
<i>B. leucopsis</i> (Bernicle „).....		12	61	131
<i>B. ruficollis</i> (Red-breasted „).....		1	142	142
<i>Nesochen sandvicensis</i> (Sandwich Island Goose)		9	50	95
<i>Chloephaga</i> , whole genus		120	32	169
<i>C. magellanica</i> (Upland Goose)		83	25	111
<i>C. melanoptera</i> (Andean „)		7	17	39
<i>C. poliocephala</i> (Ashy-headed „)		8	54.5	169
<i>C. rubidiceps</i> (Ruddy-headed „)		22	56	162
<i>Chenonetta jubata</i> (Maned „)		21	62	187

Geese are popularly reputed to have a very high potential longevity; Mr. J. H. Gurney (*loc. cit.* p. 39) mentions, on the somewhat doubtful authority of Willughby, a domestic Goose, 80 years old, and on more exact authority a *Cereopsis* of 33 years and a Bernicle Goose of 32 years. The highest figure on my list is 24 years for a Little Goose; but the maximum and average durations (the latter in many cases are lowered by the inclusions of broods of goslings) show that these birds have a high viability.

ANATINÆ.		No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Dendrocygna</i> , whole genus.....		99	30	242
<i>D. arborea</i> (Black-billed Tree-duck)...		6	11	53
<i>D. arcuata</i> (Wandering „ „)... ..		14	22.5	66
<i>D. autumnalis</i> (Red-billed „ „)... ..		32	42	242
<i>D. eytoni</i> (Eyton's „ „)... ..		2	27.5	29
<i>D. fulva</i> (Fulvous „ „)... ..		5	44	76
<i>D. javanica</i> (Indian „ „)... ..		8	18	48
<i>D. major</i> (Larger „ „)... ..		11	24	57
<i>D. viduata</i> (White-faced „ „)... ..		21	26	57
<i>Chenalopex egyptiaca</i> (Egyptian Goose)		16	34	128
<i>C. jubatus</i> (Orinoco Goose)		14	27	82
<i>Tadorna</i> , whole genus		109	40	214
<i>T. casarca</i> (Ruddy Sheldrake)		22	42	214
<i>T. cornuta</i> (Common „ „).....		31	23	111
<i>T. tadornoides</i> (Australian „ „).....		15	52	186
<i>T. variegata</i> (Variegated „ „).....		41	47	172
<i>Anas</i> , whole genus		117	36.5	319
<i>A. boscas</i> (Wild Duck)....		19	49	217
<i>A. cristata</i> (Crested „ „)... ..		2	72.5	112
<i>A. obscura</i> (Dusky „ „)... ..		5	93	146
<i>A. pæcilorhyncha</i> (Spot-billed „ „)... ..		37	33	127

ANATINÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Anas specularis</i> (White-marked Duck)	1	11	11
<i>A. superciliosa</i> (Australian Wild „)	45	42	190
<i>A. undulata</i> (Yellow-billed „)	8	85	319
<i>Chaulelasmus streperus</i> (Gadwall) ...	10	50·5	122
<i>Mareca penelope</i> (Wigeon).....	41	59·5	155
<i>M. sibilatrix</i> (Chiloe Wigeon)	37	48	185
<i>Dafila acuta</i> (Pintail).....	21	55	214
<i>D. spinicauda</i> (Chilian Pintail).....	67	40·5	273
<i>Pecilonetta bahamensis</i> (Bahama Duck)	24	59·7	170
<i>P. erythrorhyncha</i> (Red-billed „)	1	128	128
<i>Nesonetta aucklandica</i> (Auckland Island Duck)	1	17	17
<i>Querquedula</i> , whole genus	192	45	208
<i>Q. brasiliensis</i> (Brazilian Teal)	34	39	126
<i>Q. castanea</i> (Chestnut-breasted Duck)	11	19	96
<i>Q. circia</i> (Garganey Duck).....	43	45	164
<i>Q. crecca</i> (Common Teal).....	43	52	152
<i>Q. cyanoptera</i> (Blue-winged „).....	5	13·6	43
<i>Q. falcata</i> (Falcated „).....	9	18	50
<i>Q. flavirostris</i> (Chilian „).....	8	35	87
<i>Q. formosa</i> (Japanese „).....	21	48	150
<i>Q. gibberifrons</i> (Slender Duck)	18	75	208
<i>Spatula clypeata</i> (Shoveller)	18	60	154
<i>Marmaronetta angustirostris</i> (Marbled Duck)	12	18	103
FULIGULINÆ.			
<i>Metopiana peposaca</i> (Rosy-billed Duck)	39	47	160
<i>Fuligula</i> , whole genus	82	42·5	193
<i>F. baeri</i> (Baer's Duck).....	5	21	47
<i>F. cristata</i> (Tufted „).....	23	40	125
<i>F. ferina</i> (Pochard)	21	60	193
<i>F. ferruginea</i> (White-eyed Duck).....	1	1	1
<i>F. marila</i> (Scaup)	8	20	73
<i>F. rufina</i> (Red-crested Pochard)	24	39	144
<i>Tachyeres cinereus</i> (Steamer Duck) ...	1	15	15
<i>Clangula glaucion</i> (Golden-eye)	20	33	164
<i>Edemia nigra</i> (Common Scoter)	1	30	30
<i>Somateria mollissima</i> (Eider Duck) ...	3	14	17
ERISMATURINÆ.			
<i>Biziura lobata</i> (Musk Duck)	2	2·5	3
MERGANETTINÆ.			
<i>Hymenolæmus malacorhynchus</i> (Soft- billed Duck)	4	35	72
MERGINÆ.			
<i>Mergus albellus</i> (Smew)	9	22	46
<i>M. merganser</i> (Goosander).....	5	35	84
<i>M. serrator</i> (Red-breasted Merganser).	3	7	18

Mr. J. H. Gurney gives (*loc. cit.* p. 39) one doubtful case of a Wild Duck of 29 years, and several well authenticated examples of various ducks ranging from 23 years downwards. The figures of maximum duration on my list are almost uniformly high, the best being a Yellow-billed Duck of 26 years', a Chilean Pintail of nearly 23 years', and a Red-billed Tree-duck of over 20 years' duration. The figures of average duration are reduced in many cases by the inclusion of a number of very short-lived birds, either ducklings or new arrivals, but none the less show a fairly consistent high viability.

Summary of Anseres.

The first question that comes into special prominence in the case of Swans, Geese and Ducks is the validity of the units on which these averages are made. The individuality of these birds is difficult to distinguish, and as in the period to which the figures relate, there was no system of marking the individuals, mistakes must have been easy to make, where opportunity occurred. The swans, geese, and a good many of the larger ducks, such as Sheldrakes, were kept in separate pens, and the chances of confusing individuals were very small. In the case of birds like the Mandarins, Summer Ducks, Wild Duck, Pintail, Teal, and so forth, a good many were kept in the same ponds, and mistakes as to individuals must have taken place. However, the numbers at any particular time during the whole period of 33 years were never very large; and if the figures of cases where individuals were very few and were kept separate be compared with those where confusion was more likely, the inference can be drawn fairly, that on the whole such mistakes have corrected each other, and that the results are fairly valid.

It is to be noticed that the familiar correlation between size and longevity does not appear in these figures of Anserine birds, although it may apply to potential longevity. There is very little to choose between the ducks and geese, and both ducks and geese on the whole show higher maximum and average durations than occur for swans. In all the Anseres the alimentary canal is relatively long, arranged in a somewhat complex fashion, and narrow in calibre; the hind-gut and caeca are, in comparison with most other birds, rather long, and capacious (except in the Mergansers, where the caeca are vestigial). They are highly intelligent birds, readily adapting themselves to new conditions and realizing quickly that they have nothing to fear from man. Except that the space given to Swans has been rather limited, the conditions have been good, as these birds, whether from the tropics or not, have been invariably given access to open air, and in most cases have spent their whole time in it. The figures of average and maximum duration show that these birds have a good viability in captivity. None the less, as the conditions are rather unusually favourable, I think the inference can be drawn that, in

proportion to their size, Anseres have not naturally very high longevity or viability.

Capt. Flower records only one example of the Anseres—an Egyptian Goose—still alive after 12 years.

COLUMBÆ.

TRERONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Sphenocercus sphenurus</i> (Wedge-tailed Pigeon).	1	35	35
<i>Vinago</i> , whole genus	7	6.4	9
<i>V. calva</i> (Bare-faced Fruit-Pigeon)	5	6	9
<i>V. crassirostris</i> (Thick-billed „) ...	1	4	4
<i>V. delalandii</i> (Delalande's „) ...	1	9	9
<i>Crocopus chlorogaster</i> (Southern Fruit-Pigeon)	1	34	34
<i>C. phænicopterus</i> (Purple-shouldered Fruit-Pigeon).	1	5	5
<i>Osmotreron bicincta</i> (Double-banded Fruit-Pigeon).	1	4	4
<i>O. vernans</i> (Parrot „ „)	2	10	14
<i>Ptilopus</i> , whole genus.....	9	5.5	22
<i>P. fasciatus</i> (Banded Fruit-Pigeon) ...	2	1	1
<i>P. jambu</i> (Jambu „ „) ...	4	6.5	22
<i>P. melanocephalus</i> (Black-headed Fruit-Pigeon).	2	10	11
<i>P. porphyraceus</i> (Purple-crowned Fruit-Pigeon).	1	1	1
<i>Globicera</i> , whole genus	5	24	65
<i>G. auroræ</i> (Aurora Island Fruit-Pigeon)	1	65	65
<i>G. pacifica</i> (Pacific „ „)	2	8.5	9
<i>G. rufigula</i> (Vinous-throated Fruit-Pigeon).	2	18.5	26
<i>Carpophaga ænea</i> (Bronze Fruit-Pigeon)	10	23.7	53
<i>C. paulina</i> (Red-naped „ „)	4	27	41
<i>Myristicivora luctuosa</i> (Nutmeg Fruit-Pigeon).	4	14	16
<i>Lophæmus antarcticus</i> (Double-crested Fruit-Pigeon).	17	13	25
COLUMBIDÆ.			
<i>Columba</i> , whole genus	138	34.7	227
<i>C. albicularis</i> (White-throated Violet Pigeon).	1	9	9
<i>C. araucana</i> (Araucanian „ „)	1	25	25
<i>C. bollii</i> (Bolle's „ „)	6	22	65
<i>C. caribbæa</i> (Ring-tailed „ „)	1	56	56
<i>C. eversmanni</i> (Eversmann's „ „)	1	68	68
<i>C. guinea</i> (Triangular-spotted „ „)	27	23	53
<i>C. gymnophthalma</i> (Naked-eyed „ „)	2	114	144
<i>C. inornata</i> (Cuban „ „)	1	40	40

COLUMBIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Columba laurivora</i> (Canary Pigeon)	4	24	37
<i>C. leucocephala</i> (White-crowned ")	10	40	79
<i>C. leuconota</i> (White-backed ")	20	33.5	80
<i>C. maculosa</i> (Spotted ")	8	43	100
<i>C. ænas</i> (Stock-Dove)	4	13	19
<i>C. palumbus</i> (Ring-Dove)	10	18	37
<i>C. picazuro</i> (Picazuro Pigeon)...	7	62	166
<i>C. plumbea</i> (Vinaceous ")...	5	45	227
<i>C. rufina</i> (Rufous ")...	1	30	30
<i>C. speciosa</i> (Specious ")...	12	19	42
<i>C. squamosa</i> (Porto Rico ")...	17	45	215
<i>Macropygia leptogrammica</i> (Narrow- barred Pigeon).	3	9	13
<i>M. phasianella</i> (Pheasant-tailed ")	2	12	23
<i>Ectopistes migratorius</i> (Passenger Pigeon).	6	23	76
<i>Zenaidura carolinensis</i> (Carolina Dove)	2	8	8
<i>Zenaida</i> , whole genus	48	25.2	80
<i>Z. amabilis</i> (Zenaida Dove)	8	25	33
<i>Z. auriculata</i> (Auriculated Dove).....	17	27.6	79
<i>Z. aurita</i> (Martinican ").....	23	23	80
<i>Nesopelia galapagoensis</i> (Galapagan Dove).	4	16.5	29
<i>Melopelia leucoptera</i> (White-winged Zenaida Dove).	2	16.5	17
<i>Turtur</i> , whole genus	139	25.5	195
<i>T. aldabranus</i> (Aldabra Turtle Dove)	3	11	19
<i>T. bitorquatus</i> (Double-ringed Turtle Dove).	1	62	62
<i>T. capicola</i> (Cape Turtle Dove)	2	8	10
<i>T. chinensis</i> (Chinese " ")	8	41	77
<i>T. communis</i> (Turtle Dove)	18	20.5	82
<i>T. orientalis</i> (Eastern Turtle Dove)	5	51	195
<i>T. risorius</i> (Barbary " ")	34	22	108
<i>T. semitorquatus</i> (Half-collared Turtle Dove).	17	36	170
<i>T. senegalensis</i> (Cambayan Turtle Dove)	20	34	145
<i>T. suratensis</i> (Spotted " ")	11	34	75
<i>T. tigrinus</i> (Tigrine " ")	1	41	41
<i>T. vinaceus</i> (Vinaceous " ")	19	52.5	177
<i>Geopelia</i> , whole genus.....	84	28.5	80
<i>G. cuneata</i> (Graceful Ground-Dove) ...	22	25	80
<i>G. humeralis</i> (Barred-shouldered Dove)	19	28	72
<i>G. maugæi</i> (Maugé's Dove).....	6	44	60
<i>G. striata</i> (Barred ").....	23	33	80
<i>G. tranquilla</i> (Peaceful ").....	14	20	47
<i>Scardafella squamosa</i> (Scaly Ground- Dove).	10	16	40
<i>Columbula picui</i> (Picui Dove)	6	6	10

COLUMBIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Chamæpelia passerina</i> (Passerine Ground-Dove).	5	11·8	27
<i>C. talpacoti</i> (Talpacoti " ")	16	30	67
<i>Peristera geoffroyi</i> (Geoffroy's Dove)	34	26·5	102
<i>Metriopelia melanoptera</i> (Black-winged Dove).	8	29·5	121
<i>Ena capensis</i> (Cape Dove)	11	28	69
<i>Tympanistria bicolor</i> (Tambourine Pigeon).	16	26	61
<i>Chalcopelia chalcospilos</i> (Bronze-spotted Dove).	17	37·5	92
<i>Chalcophaps chrysochlora</i> (Little Green- winged Dove).	5	32	61
<i>C. indica</i> (Green-winged Dove).....	23	35	193
<i>Calopelia puella</i> (Schlegel's ").....	18	21	109
<i>Phaps</i> , whole genus	38	24·5	98
<i>P. chalcoptera</i> (Bronze-winged Pigeon)	34	24	98
<i>P. elegans</i> (Brush " " ")	3	20	28
<i>P. histrionica</i> (Harlequin Bronze- winged Pigeon).	1	60	60
<i>Geophaps plumifera</i> (Plumed Ground- Dove).	9	26	66
<i>G. scripta</i> (Partridge Bronze-winged Pigeon).	5	16	24
<i>Ocyphaps lophotes</i> (Crested Pigeon) ...	49	22	64
<i>Haplopelia larvata</i> (Rufous-necked Wood-Dove).	2	14	16
<i>Leptoptila</i> , whole genus	16	28	103
<i>L. jamaicensis</i> (White-fronted Dove)	5	40	103
<i>L. ochroptera</i> (Orange-winged ")	2	11	14
<i>L. rufaxilla</i> (Red-under-winged ")	9	25	81
<i>Geotrygon</i> , whole genus	22	27	56
<i>G. cristata</i> (Mountain-witch Ground- Dove).	4	17	25
<i>G. montana</i> (Red Ground-Dove)	14	30	56
<i>G. mystacea</i> (Moustache Ground-Dove)	4	29	54
<i>Phlogoenas luzonica</i> (Blood-breasted Pigeon).	29	24	79
<i>P. stairi</i> (Stair's Ground-Dove).....	2	14·5	18
<i>Leucosarcia picata</i> (Wonga-Wonga Pigeon).	22	50	171
<i>Staroenas cyanocephala</i> (Blue-headed Pigeon).	13	20	44
<i>Caloenas nicobarica</i> (Nicobar " ")	23	51	109
<i>Goura coronata</i> (Common Crowned Pigeon).	30	23	110
<i>G. victorie</i> (Victoria Crowned " ")	10	58	142
<i>Didunculus strigirostris</i> (Toothed- billed Pigeon).	3	30	53

Summary of Columbeæ.

Mr. J. H. Gurney (*loc. cit.* p. 39) gives on the authority of Mr. F. E. Blaauw several instances of long-lived Collared Doves (*Turtur risorius*), ranging from 40 to 30 years, and a Common Pigeon of 28½ years; a correspondent of my own, Mr. E. Mellin, has informed me of a Ring-Dove of over 23 years old. The figures of maximum duration on my list are therefore not surprising: they include a Vinaceous Pigeon of just under 19 years, a Porto Rico Pigeon of just under 18 years, an Eastern Turtle-Dove and a Green-winged Dove of over 16 years. The maximum durations are on the whole good; certainly in proportion to size better than in the Anseres. The figures of average duration are much lower in the Fruit Pigeons, in which they seldom exceed 2 years and are frequently under 1 year, than in the Columbidae, where they mostly range from 2 to 5 years. I cannot see any good correlation within the group, between size and viability.

Pigeons have a long and complex alimentary tract, with, however, the posterior portion and cæca relatively much reduced. They have been kept under various conditions in the period under discussion, but most of the tropical forms have been placed in a heated aviary, sometimes with, sometimes without access to the open air.

Capt. Flower's highest record is that of a Green-winged Dove, alive after 6 years' duration.

PTEROCLETES.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Pterocles</i> , whole genus.....	67	20·5	94
<i>P. alchata</i> (Pin-tailed Sand-grouse) ...	18	15	34
<i>P. arenarius</i> (Black-bellied Sand- grouse).	27	21	55
<i>P. bicinctus</i> (Double-banded Sand- grouse).	9	17	32
<i>P. exustus</i> (Little Pin-tailed Sand- grouse).	11	31	94
<i>P. fasciatus</i> (Banded Sand-grouse)	1	24	24
<i>P. namaqua</i> (Namaqua " ")	1	15	15
<i>Syrphaptles paradoxus</i> (Pallas' Sand- grouse).	16	8	14

I had no previous information as to the longevity of Sand-grouse. The maximum durations, of which the highest is under 8 years, and the average durations, most of which are considerably less than 2 years, show that these birds, in proportion to their size, are less viable than Doves and Pigeons. Their alimentary tract is somewhat similar to that of Pigeons, but the hind-gut and cæca are relatively capacious. In the period under consideration Sand-grouse were placed in an aviary with heated interior and open-air runs.

Capt. Flower records Spotted Sand-grouse (*P. senegallus*) still alive after over 9 years' duration; a year longer than the highest record I give.

GALLINÆ.

TETRAONIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tetrao</i> , whole genus	11	9·7	50
<i>T. cupido</i> (Prairie Grouse).....	7	5·5	17
<i>T. phasianellus</i> (Sharp-tailed Grouse) .	2	26	50
<i>T. urogallus</i> (Capercaillie)	2	8·5	15
PHASIANIDÆ.			
<i>Galloperdix</i> , whole genus	5	18·6	64
<i>G. lunulata</i> (Hardwicke's Spur-fowl) .	1	1	1
<i>G. spadicea</i> (Rufous " ") .	2	44·5	64
<i>G. zeylonensis</i> (Ceylonese " ") .	2	1·5	2
<i>Ithaginis geoffroyi</i> (Geoffroy's Blood-Pheasant).	1	14	14
<i>Ptilopachys ventralis</i> (Buff-breasted Partridge).	2	27·5	31
<i>Francolinus</i> , whole genus	68	15	62
<i>F. bicalcaratus</i> (Double-spurred Francolin).	7	6·5	21
<i>F. capensis</i> (Cape Francolin).....	1	4·2	4
<i>F. clappertoni</i> (Clapperton's Francolin).	8	30·5	54
<i>F. coqui</i> (Coqui " ") .	5	18·8	32
<i>F. granti</i> (Grant's " ") .	2	21·5	26
<i>F. gularis</i> (Wood " ") .	3	18·6	36
<i>F. kirki</i> (Kirk's " ") .	2	3·5	4
<i>F. levaillanti</i> (Levaillant's " ") .	1	7	7
<i>F. natalensis</i> (Natal " ") .	1	1	1
<i>F. pictus</i> (Painted " ") .	1	10	10
<i>F. ponticerianus</i> (Grey " ") .	19	17	62
<i>F. vulgaris</i> (Black " ") .	18	11	43
<i>Pternistes</i> , whole genus	29	15·8	51
<i>P. afer</i> (Grey-winged Francolin)	7	12	22
<i>P. infuscatus</i> (Dusky " ")	1	18	18
<i>P. leucoscepus</i> (White-shafted " ")	7	7	24
<i>P. nudicollis</i> (Bare-necked " ")	7	26	51
<i>P. swainsoni</i> (Swainson's " ")	7	16	23
<i>Arboricola atrogularis</i> (Black-throated Francolin).	1	9	9
<i>A. torqueola</i> (Hill Francolin).....	5	19	62
<i>Bambusicola fytchii</i> (Fytch's Francolin).	1	19	19
<i>B. thoracica</i> (Bamboo Partridge)	15	24	80
<i>Perdix cinerea</i> (Partridge)	14	14	28
<i>P. hodgsoni</i> (Hodgson's Partridge)...	4	16	24
<i>Coturnix</i> , whole genus	108	22·3	85
<i>C. chinensis</i> (Chinese Quail).....	23	19	41
<i>C. communis</i> (Common " ").....	54	22	85
<i>C. coromandelica</i> (Rain " ").....	15	27	59
<i>C. histrionica</i> (Harlequin " ").....	12	21	40
<i>C. pectoralis</i> (Pectoral " ").....	4	25	34

PHASIANIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Synæcus australis</i> (Australian Quail)	10	26·7	57
<i>Perdica argoondah</i> (Marbled ")	1	28	28
<i>P. asiatica</i> (Asiatic ")	10	12·4	27
<i>Rollulus cristatus</i> (Crowned ")	8	9	20
<i>Odontophorus dentatus</i> (Capoeira ")	9	9·9	29
<i>O. guianensis</i> (Guiana ")	8	7·4	17
<i>Ortyx virginianus</i> (Virginian Colin)	11	11	38
<i>Eupsychortyx cristatus</i> (Crested ")	27	14	58
<i>E. leylandii</i> (Leyland's Colin)	1	43	43
<i>Callipepla</i> , whole genus	72	18	91
<i>C. californica</i> (Californian Quail)	57	17	91
<i>C. gambelli</i> (Gambel's ")	7	26	49
<i>C. squamata</i> (Mexican ")	8	18	46
<i>Caccabis</i> , whole genus	59	12	50
<i>C. chukar</i> (Chukar Partridge)	27	11	50
<i>C. melanocephala</i> (Black-headed Partridge).	3	9	20
<i>C. petrosa</i> (Barbary Partridge)	10	13	50
<i>C. rufa</i> (Red-legged ")	10	9·5	31
<i>C. saxatilis</i> (Greek ")	9	15	32
<i>Ammoperdix bonhami</i> (Bonham's Partridge).	3	20	41
<i>A. heyi</i> (Hey's Partridge)	2	15·5	19
<i>Tetraogallus himalayensis</i> (Himalayan Snow Partridge).	1	3	3
<i>Lophophorus</i> , whole genus	56	23·6	123
<i>L. impeyanus</i> (Himalayan Monaul)	54	23	123
<i>L. lhuysi</i> (Lhuys's ")	1	54	54
<i>L. sclateri</i> (Sclater's ")	1	20	20
<i>Crossoptilon mantchuricum</i> (Mantchurian Crossoptilon)	20	22·8	42
<i>C. tibetanum</i> (Tibetan ")	7	22	32
<i>Phasianus</i> , whole genus	174	25·5	95
<i>P. colchicus</i> (Common Pheasant)	11	26	85
<i>P. decollatus</i> (Collarless ")	1	18	18
<i>P. ellioti</i> (Elliot's ")	32	32	76
<i>P. principalis</i> (Prince of Wales's ")	4	18	46
<i>P. reevesi</i> (Bar-tailed ")	57	22·8	64
<i>P. scemmerringi</i> (Scemmerring's ")	9	36	95
<i>P. torquatus</i> (Ring-necked ")	16	20	70
<i>P. versicolor</i> (Japanese ")	27	20	86
<i>P. walkichii</i> (Cheer ")	17	31	79
<i>Thaumalea amherstiae</i> (Lady Amherst's Pheasant)	87	20	97
<i>T. picta</i> (Gold Pheasant)	75	22·5	93
<i>Pucrasia</i> , whole genus	21	8·6	24
<i>P. darwini</i> (Darwin's Pucras)	19	9	24
<i>P. macrolopha</i> (Indian ")	1	3	3
<i>P. xanthospila</i> (Yellow-spotted ")	1	4	4

PHASIANIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Euplocamus</i> , whole genus	155	24·8	161
<i>E. albo-cristatus</i> (White-crested Kaleege)	12	36	76
<i>E. andersoni</i> (Anderson's ")	1	11	11
<i>E. erythrophthalmus</i> (Rufous-tailed Pheasant)	18	20	109
<i>E. horsfieldi</i> (Purple Kaleege)	7	46	108
<i>E. lineatus</i> (Lineated ")	19	22	76
<i>E. melanotus</i> (Black-headed ")	8	45	161
<i>E. nycthemerus</i> (Silver Pheasant).....	38	23	114
<i>E. nobilis</i> (Fire-back ").....	8	37	116
<i>E. praelatus</i> (Siamese ").....	8	40	111
<i>E. swinhoei</i> (Swinhoe's ").....	32	12	66
<i>E. vieilloti</i> (Vieillot's Fire-back)	4	11	21
<i>Gallus</i> , whole genus	39	22·7	148
<i>G. bankiva</i> (Bankiva Jungle-fowl)...	5	8	36
<i>G. sonnerati</i> (Sonnerat's " ")... 12	12	31	148
<i>G. stanleyi</i> (Ceylonese " ")... 11	11	18	36
<i>G. varius</i> (Fork-tailed " ")... 11	11	23	62
<i>Cerionis</i> , whole genus	71	29	133
<i>C. blythi</i> (Blyth's Tragopan)	5	38	133
<i>C. caboti</i> (Cabot's " ")..... 6	6	31	72
<i>C. melanocephala</i> (Black-headed Tragopan)	2	26·5	28
<i>C. satyra</i> (Horned " ")	21	19	58
<i>C. temmincki</i> (Temminck's " ")	37	30·5	123
<i>Pavo</i> , whole genus	99	22·6	98
<i>P. cristatus</i> (Common Peafowl)	66	24	98
<i>P. nigripennis</i> (Black-winged " ")	15	26	73
<i>P. spicifer</i> (Javan " ")	18	13	47
<i>Polyplectron</i> , whole genus	47	50	179
<i>P. bicalcaratum</i> (Crested Peacock Pheasant)	2	23	41
<i>P. chinquis</i> (Peacock Pheasant)	39	55	179
<i>P. germaini</i> (Germain's Peacock Pheasant).	6	22	47
<i>Argus giganteus</i> (Argus Pheasant).	22	42	163
<i>Meleagris gallopavo</i> (North American Turkey).	12	26	62
<i>M. ocellata</i> (Ocellated Turkey)	2	2·5	3
<i>Numida</i> , whole genus	34	17·7	40
<i>N. ellioti</i> (Elliot's Guinea-fowl)	1	5	5
<i>N. meleagris</i> (Common " ")	8	28	40
<i>N. nitrata</i> (Mitred " ")	11	16	30
<i>N. ptilorhyncha</i> (Abyssinian " ")	13	14	40
<i>N. reichenowi</i> (Reichenow's " ")	1	17	17
<i>Guttera</i> , whole genus	23	16	54
<i>G. cristata</i> (Crested Guinea-fowl)	12	17	54
<i>G. edouardi</i> (Verreaux's " ")	1	21	21

PHASIANIDÆ (<i>cont.</i>).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Guttera pucherani</i> (Pucheran's Guinea-fowl).	10	14.4	28
<i>Acryllium vulturinum</i> (Vulturine Guinea-fowl).	34	20	101
CRACIDÆ.			
<i>Crax</i> , whole genus	83	46.8	124
<i>C. alberti</i> (Prince Albert's Curassow)	11	47	104
<i>C. alector</i> (Crested ")	13	40	118
<i>C. carunculata</i> (Yarrell's ")	12	46	106
<i>C. daubentonii</i> (Daubenton's ")	12	40.7	93
<i>C. globicera</i> (Globose ")	19	40.7	119
<i>C. globulosa</i> (Globulose ")	2	59	103
<i>C. incommoda</i> (Inconvenient ")	2	29	50
<i>C. sclateri</i> (Sclater's ")	12	62	124
<i>Mitua tomentosa</i> (Lesser Razor-billed Curassow).	4	68	133
<i>M. tuberosa</i> (Razor-billed ")	7	71.7	139
<i>Pauxis galeata</i> (Galeated ")	3	70	102
<i>Nothocrax urumutum</i> (Urumutum Curassow).	3	37	49
<i>Penelope</i> , whole genus	50	32	105
<i>P. cristata</i> (Rufous-vented Guan)	14	27	82
<i>P. greeyi</i> (Greey's ")	2	15	20
<i>P. jacucaca</i> (White-fronted ")	11	34	65
<i>P. marail</i> (Marail ")	1	18	18
<i>P. pileata</i> (Red-breasted ")	3	50	63
<i>P. purpurascens</i> (Purplish ")	7	38	77
<i>P. supercilialis</i> (White-eyebrowed ")	12	32	105
<i>Pipile</i> , whole genus	7	23	37
<i>P. cujubi</i> (Amazonian Guan)	3	30	37
<i>P. cumanensis</i> (Piping Guan)	3	20	27
<i>P. jacutinga</i> (White-crested ")	1	12	12
<i>Alburria carunculata</i> (Wattled ")	2	21	21
<i>Ortalis</i> , whole genus	20	26.5	100
<i>O. albiventris</i> (White-bellied Guan)	8	27	100
<i>O. garrula</i> (Chattering ")	1	66	66
<i>O. motmot</i> (Little ")	4	7.5	19
<i>O. ruficauda</i> (Red-tailed ")	3	28	50
<i>O. vetula</i> (Mexican ")	4	32	39

MEGAPODIIDÆ.

<i>Talegalla lathamii</i> (Brush-Turkey).....	13	59	236
<i>Megacephalon maleo</i> (Great-headed Maleo).	3	5	9
<i>Leipoa ocellata</i> (Mallee Bird).....	1	24	24

Summary of Gallinæ.

Mr. J. H. Gurney (*loc. cit.* p. 39) gives a few interesting figures for Gallinaceous birds, including domestic fowls of 30, 25 and 24 years, and a Silver Pheasant of 21 years. The maximum

durations on my list include some fairly high figures—a Brush-Turkey of over 19 years, a Peacock Pheasant of nearly 15 years, Argus and Kaleege Pheasants over 13 years, a Monaul of over 10 years and a Common Quail of over 7 years. Taking Gallinæ as a whole there is no close correlation between size and duration. The Grouse are the least viable in captivity, the average durations being nearly all under a year, and 4 years being the maximum. The Francolins, Quails, and Partridges have an average duration most often between 1 and 2 years, with a few good figures of maximum duration. The Pheasants, Peacocks, and Jungle-Fowl for the most part have average durations exceeding 2 years, and reach 13 to 15 years maximum. Sir E. G. Loder, Bt., F.Z.S., however, has told me of a Peacock still alive at a house near Aylesbury, and which is certainly 40 years old. The Curassows and Guans appear to be specially viable; there is a remarkable uniformity amongst the individual durations, these lying very close to the average, which is generally over 3 years.

The structure of the intestinal tract does not differ much in Gallinaceous birds: in all the gut is relatively capacious, although not specially long, and the posterior portion including the cæca is long and capacious compared to the whole gut. It is perhaps not more than a coincidence that the hind-gut and cæca are relatively least capacious in the Megapodes, next least capacious in the Curassows, and most capacious in the other Gallinaceous birds, whilst the Megapodes show the best maximum duration, and the Curassows the highest average durations in the group. The conditions under which the birds of this group were kept during the period in question did not differ much; all had access to open air, and the smaller Quails, Partridges and so forth, and the Curassows had warmed shelters, whilst the others had unheated sheds. Considering the more or less favourable conditions, and the large size of many of the Gallinaceous birds, it cannot be said that they display a good constitutional viability.

Capt. Flower's records are closely comparable with the maxima I give here. He notes a Clapperton's Francolin still alive after 6 years, my highest record being 5 years; a Quail of over 7 years, the same maximum as mine; an Amherst Pheasant of 11 years' duration, and a Silver Pheasant still alive after 12 years; these are higher than the records of the same species I quote, but, on the other hand, I cite a Black-headed Kaleege of 13 years and a Peacock Pheasant of 15 years.

HEMIPODIÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Turnia</i> , whole genus	15	9	26
<i>T. dussumieri</i> (Little Bittern Quail)...	2	2·5	4
<i>T. lepurana</i> (Lepurana Hemipode) ...	3	17	26
<i>T. sykesi</i> (Sykes's ") ...	2	8	16
<i>T. taigoor</i> (Black-breasted ") ...	2	1	1
<i>T. tanki</i> (Tipperah ") ...	2	1	1
<i>T. varia</i> (Varied ") ...	4	16	25

I am ignorant of any figures hitherto recorded as to the longevity of Hemipodes. My figures show a very low viability both from the point of view of average and maximum durations. The birds were kept during the period dealt with under the same conditions as the small Francolins, Quails and Partridges. The alimentary tract is relatively short but capacious, the hind-gut and cæca being very capacious relatively to the size of the birds. The group has a low viability.

FULICARÆ.

RALLIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Rallus</i> , whole genus	24	21·3	51
<i>R. aquaticus</i> (Water-Rail)	10	13·9	35
<i>R. celebensis</i> (Celebean Rail)	3	36	48
<i>R. maculatus</i> (White-spotted Rail) ...	3	26	48
<i>R. pectoralis</i> (Australian ") ...	6	19·5	35
<i>R. rhytirhynchus</i> (Sooty ") ...	2	36	51
<i>Aramides cayennensis</i> (West-Indian Rail)	19	10	26
<i>A. ypecaha</i> (Ypecaha Rail)	11	15·5	39
<i>Porzana</i> , whole genus	5	30	59
<i>P. carolina</i> (Carolina Crane)	2	22·5	28
<i>P. maruetta</i> (Spotted ")	2	29	29
<i>P. notata</i> (Marked ")	1	59	59
<i>Rallina peciloptera</i> (Bar-winged Rail)	1	2	2
<i>Crex pratensis</i> (Corn Crane)	16	22	101
<i>Ocydromus</i> , whole genus	30	52	117
<i>O. australis</i> (Weka Rail)	17	49	117
<i>O. earli</i> (Earl's " ")	8	64	107
<i>O. fuscus</i> (Black Woodhen)	1	50	50
<i>O. lafresnayanus</i> (New Caledonian Rail)	2	43·5	76
<i>O. sylvestris</i> (Woodhen Rail)	2	38·5	66
<i>Limnocorax niger</i> (Black Gallinule) ...	2	52·5	89
<i>Porphyrio</i> , whole genus	53	23·5	75
<i>P. calvus</i> (Javan Porphyrio)	1	1	1
<i>P. cæruleus</i> (Purple Gallinule)	4	21	32
<i>P. edwardsi</i> (Milne Edwards's Porphyrio)	2	18·5	22
<i>P. madagascariensis</i> (Madagascar Porphyrio)	17	18	59
<i>P. melanotus</i> (Black-backed ")	19	25	73
<i>P. poliocephalus</i> (Grey-headed ")	9	32	75
<i>P. vitiensis</i> (Grey-blue ")	1	23	23
<i>Hydroornia alleni</i> (Allen's ")	13	17	47
<i>Ionornis martinicus</i> (Martinique Gallinule)	8	17	30
<i>Tribonyx mortieri</i> (Mortier's Waterhen).	1	102	102
<i>T. ventralis</i> (Black-tailed Waterhen).	3	85	162

RALLIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Gallinula</i> , whole genus	20	25·5	42
<i>G. chloropus</i> (Moorhen)	9	30	42
<i>G. galeata</i> (American Moorhen)	2	21	29
<i>G. nesiotis</i> (Island-Hen Gallinule)	3	25	35
<i>G. phœnicura</i> (White-breasted „)	4	12·5	26
<i>G. pyrrhorhoa</i> (Madagascar Moorhen)	2	38·5	42
<i>Fulica</i> , whole genus	8	14	36
<i>F. ardesiaca</i> (Slaty Coot)	2	18·5	36
<i>F. atra</i> (Coot)	4	16	21
<i>F. leucoptera</i> (Strickland's Coot)	2	6	9

Summary of Fulicarice.

I have discovered few published statements as to the longevity of Rails and Crakes, but Mr. J. H. Gurney (*loc. cit.* p. 38) has mentioned Porphyrios of 19 and 14 years. The highest figure on my list is that for a Black-tailed Waterhen with a duration of over 13 years; then come a Weka Rail of over 9 years; a Corn Crake of 8 years, and then figures ranging downwards. The average durations range rather closely round 2 years. The intestinal tract of Rails and their allies is of moderate length and capacity, the posterior portion with the cæca being rather capacious. These birds in the period in question have been kept either in open-air paddocks, or in an aviary with heated interior and access to open air. There is not a very wide gap between the figures of average and maximum durations; there is no appreciable correlation between size and longevity, and considering the rather favourable conditions under which the birds were kept, they appear to have a rather low viability in proportion to their size.

Capt. Flower's highest record is a Gallinule still alive after 6 years' duration.

ALECTORIDES.

OTIDIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Otis tarda</i> (Great Bustard)	16	30	128
<i>Eupodotis</i> , whole genus	13	50·7	106
<i>E. arabs</i> (Arabian Bustard)	2	59	91
<i>E. australis</i> (Australian „)	4	73	106
<i>E. caffra</i> (Kaffir „)	1	9	9
<i>E. denhami</i> (Denham's „)	3	60	98
<i>E. kori</i> (Burchell's „)	2	24	42
<i>E. ruficollis</i> (Red-necked „)	1	10	10
<i>Houbara macqueeni</i> (Macqueen's Bustard)	8	9	25
<i>H. undulata</i> (Houbara Bustard)	7	3	9

I have found no other figures published as to the longevity of Bustards. The maximum duration on my list, of nearly 11 years

for a Great Bustard, is no great age for so large a bird; the figures of average duration are fairly good in comparison with the maximum durations. These birds have been kept almost altogether in open-air paddocks, and it would appear that their constitutional viability is not high in proportion to their size. The whole alimentary tract is very short in proportion to the size of the birds, but the hind-gut and cæca are relatively extremely capacious.

PSOPHIIDÆ & CARIAMIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Psophia</i> , whole genus	30	17·7	90
<i>P. crepitans</i> (Common Trumpeter) ...	15	17·5	90
<i>P. leucoptera</i> (White-backed „) ...	6	19·5	34
<i>P. viridis</i> (Green-winged „) ...	9	16·5	32
<i>Cariama cristata</i> (Brazilian Cariama)	20	49	151
<i>Chunga burmeisteri</i> (Burmeister's Cariama).	6	31	65

I do not know of any published references to the ages of Trumpeters and Cariamas. The alimentary tract of these birds is much of the same character as that of the Bustards, but the cæca and hind-gut are relatively rather less capacious. The birds have been kept in an aviary with heated interior and open-air compartments. The record of between 12 and 13 years for a Brazilian Cariama, and the figures of average duration appear to show that the Cariamas have a higher viability than the Trumpeters. The former are larger birds, and the difference may be merely the familiar size correlation.

GRUIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Grus</i> , whole genus	42	72	514
<i>G. americana</i> (American Crane)	5	34	82
<i>G. antigone</i> (Eastern Sarus „)	7	64	191
<i>G. australasiana</i> (Australian Crane)	10	68	129
<i>G. canadensis</i> (Canadian „)	4	35	96
<i>G. communis</i> (Common „)	7	145	514
<i>G. japonensis</i> (Manchurian „)	8	59	306
<i>G. monachus</i> (Hooded „)	1	99	99
<i>Anthropoides</i> , whole genus	40	46·5	227
<i>A. carunculata</i> (Wattled Crane)	9	34	59
<i>A. leucauchen</i> (White-necked Crane)	1	184	184
<i>A. leucogeranos</i> (Asiatic White „)	9	34	84
<i>A. paradisea</i> (Stanley „)	8	58	227
<i>A. virgo</i> (Demoiselle „)	13	46	104
<i>Balearica pavonina</i> (Crowned „)	7	50	141
<i>B. regulorum</i> (Cape „)	14	43	170

Mr. J. H. Gurney has recorded (*loc. cit.* p. 38) a Common Crane of 40 years (from the Gardens of this Society) and a White-necked Crane of 28 years from the Amsterdam Gardens. The longest

duration on my list is a Common Crane which lived in the Gardens for nearly 43 years, another of the same species with a duration of $27\frac{1}{2}$ years, and a Manchurian Crane of $25\frac{1}{2}$ years. It is clear that these large birds have a very high potential longevity. The alimentary tract is relatively very long and of narrow calibre, but the cæca and hind-gut are by no means capacious in proportion to the whole tract. In the period to which the figures relate, the Cranes were kept in an open-air paddock, a few being taken indoors in winter. The maximum durations, and the average durations, ranging from nearly three years upwards, show that these birds have a high viability.

EURYPYGIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Eurypyga helias</i> (Sun-bittern)	11	48	114
<i>Rhinochetus jubatus</i> (Kagu)	6	137	196

I do not know of any published figures relating to the longevity of the isolated birds here placed together. The individual examples of the Sun-bittern differed considerably in duration: all but one of the six Kagus lived at least 9 years in the Gardens, the maximum duration being over 16 years. They were kept under similar conditions, in an aviary with warmed retreats and access to open air. The maximum durations and average durations show that both have a high potential longevity and viability in proportion to their size, but that the Kagu is harder than the Sun-bittern. In each case the alimentary tract is, relatively to the size of the bird, rather long, but the posterior region and cæca are uncapacious.

ARAMIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Aramus scolopaceus</i> (Scolopaceous Coulan).	1	9	9

I cannot draw any conclusion from the single example of this bird. From the structure of the alimentary tract, I am disposed to regard this bird as less viable than Cranes, Bustards, Sun-bitterns and so forth.

Summary of Alectorides.

Most naturalists would agree that the association of the birds here grouped as Alectorides (following the Society's Vertebrate List) is not intimate. It is quite plain that within the assemblage there is no good correlation between size and longevity and viability. The Cranes, it is true, show the longest durations and very good averages, but the Kagus, which are much smaller, are nearly as good, whilst the Bustards, which are large and bulky birds, are much worse. If we make, so to say, a correction for size, discounting the expected greater longevity of the larger forms, then the birds in the assemblage might be arranged as follows, in the order of good to less good viability—Kagus, Cranes, Sun-bitterns, Cariamias, Trumpeters, Bustards generally, and lowest of all Houbara Bustards.

LIMICOLÆ.

ÆDICNEMIDÆ.	No. of Indiv.	Av. dur. in monthls.	Max. dur. in months
<i>Edicnemus</i> , whole genus	31	18	117
<i>E. bistratus</i> (Double-striped Thicknee)	4	63	117
<i>E. grallarius</i> (Australian ")	8	13	43
<i>E. scolopax</i> (Stone-Curlew)	11	10·8	23
<i>E. superciliaris</i> (Peruvian Thicknee)	8	19·8	53

CHARADRIIDÆ.

<i>Charadrius plumialis</i> (Golden Plover)	27	9	23
<i>Squatarola helvetica</i> (Grey ")	15	16·5	58
<i>Agialitis curonica</i> (Little Ringed ")	2	40·5	55
<i>Æ. hiaticula</i> (Ringed ")	9	8	14
<i>Eudromias morinellus</i> (Dotterel)	1	6	6
<i>Vanellus cayennensis</i> (Cayenne Lapwing)	19	31	106
<i>V. cristatus</i> (= <i>vulgaris</i>) (Lapwing) ...	31	11	38
<i>Sarciophorus pectoralis</i> (Black-breasted Peewit)	7	71	170
<i>Streptilas interpres</i> (Turnstone)	6	66·5	92
<i>Hematopus niger</i> (Black Oyster-catcher)	2	29	49
<i>H. ostralegus</i> (Oyster-catcher)	28	28	85
<i>Glareola ocularis</i> (Eye-marked Pratincole)	1	40	40
<i>G. pratincola</i> (Pratincole)	10	23·3	81

CHIONIDÆ.

<i>Chionis alba</i> (Yellow-billed Sheathbill)	12	21	89
<i>C. minor</i> (Black-billed ")	2	24·5	27

SCOLOPACIDÆ.

<i>Recurvirostra avocetta</i> (Avocet).....	9	13	64
<i>Himantopus brasiliensis</i> (Brazilian Stilt-Plover)	1	3	3
<i>H. nigricollis</i> (Black-necked Stilt).....	12	11·5	26
<i>Scolopax rusticola</i> (Woodcock)	6	16	67
<i>Gallinago caelestis</i> (Snipe)	1	1	1
<i>Tringa alpina</i> (Dunlin)	55	6	42
<i>T. canutus</i> (Knot)	44	25	94
<i>Machetes pugnax</i> (Ruff)	5	17	50
<i>Calidris arenaria</i> (Sanderling)	1	8	8
<i>Tringoides hypoleucus</i> (Common Sand-piper)	4	21	37
<i>Totanus calidris</i> (Redshank)	19	15	71
<i>T. fuscus</i> (Spotted ")	1	35	35
<i>Limosa cecocephala</i> (Black-tailed Godwit)	4	12·5	24
<i>L. lapponica</i> (Bar-tailed Godwit)	3	7	19
<i>Numenius</i> , whole genus	25	31	180
<i>N. arquata</i> (Curlew)	20	21	80
<i>N. femoralis</i> (Pacific Curlew).....	2	131	180
<i>N. phaeopus</i> (Whimbrel).....	3	32	41

Summary of Limicolæ.

Mr. J. H. Gurney (*loc. cit.* p. 40) records an Oyster-catcher of 30 years, and a Ruff of 10 years. The highest figures of maximum duration on my list are 15 years for a Pacific Curlew and over 14 years for a Black-breasted Peewit, but there is at present alive in the Gardens a Wattled Lapwing (*Lobivanellus lobatus*) which we have had for nearly 20 years, and an Oyster-catcher which we have had for 13 years. The average durations on the list are in most cases between 1 and 2 years. In the period in question these birds were kept in an artificially warmed aviary, with or without access to open air, the best figures relating to species usually kept in an aviary with open-air cages. The structure of the alimentary canal of these birds is on the same general type—relatively very long and of slender calibre, with in the less specialized forms the cæca and hind-gut relatively more capacious, but seldom conspicuously so. The usual failure with common European birds is noteworthy, and would appear still more clearly if I had not omitted from the figures numerous cases of individuals that lived less than a month at the Gardens. The evidence appears to show that in proportion to their size Limicolous birds have a high potential longevity, but that either their viability is constitutionally low, or the conditions of captivity are unfavourable to them.

Capt. Flower's highest record is a Lapwing still alive after 6 years' duration.

GAVIÆ.

STERCORARIIDÆ.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Stercorarius</i> , whole genus	14	14·6	67
<i>S. antarcticus</i> (Antarctic Skua)	6	18	67
<i>S. buffoni</i> (Buffon's ")	1	2	2
<i>S. crepidatus</i> (Richardson's ")	2	1	1
<i>S. pomatorhinus</i> (Pomatorhine ")	5	19	47

LARIDÆ.

<i>Phaethusa magnirostris</i> (Great-billed Tern)	1	2	2
<i>Gelochelidon anglica</i> (Gull-billed ")	1	10	10
<i>Sterna</i> , whole genus	12	11·6	74
<i>S. cantiaea</i> (Sandwich Tern)	4	2·7	3
<i>S. fluviatilis</i> (Common ")	7	16	74
<i>S. minuta</i> (Little ")	1	16	16
<i>Larus</i> , whole genus	190	42·5	257
<i>L. argentatus</i> (Herring Gull)	34	27·8	99
<i>L. atricilla</i> (Laughing ")	6	26	50
<i>L. brunneicephalus</i> (Brown-headed Gull)	1	55	55
<i>L. cachinnans</i> (Yellow-legged Herring Gull)	11	77	230

LARIDÆ (cont.).	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Larus canus</i> (Common Gull)	27	30·9	77
<i>L. cirrhocephalus</i> (Ashy-headed Gull)	3	47	94
<i>L. dominicanus</i> (Dominican ")	5	101	114
<i>L. franklini</i> (Franklin's ")	3	10	16
<i>L. fuscus</i> (Lesser Black-backed ")	11	32·8	97
<i>L. gelastes</i> (Arabian ")	1	10	10
<i>L. glaucus</i> (Glaucous ")	6	58·5	156
<i>L. ichthyaetus</i> (Great Black-headed ")	2	6·5	7
<i>L. leucopterus</i> (Iceland ")	1	93	93
<i>L. marinus</i> (Greater Black-backed ")	8	74	187
<i>L. novæ-hollandiæ</i> (Jameson's ")	14	60	255
<i>L. ridibundus</i> (Black-headed ")	57	40	257
<i>Pagophila eburnea</i> (Ivory ")	5	20	55
<i>Rissa tridactyla</i> (Kittiwake)	18	10·5	55

Summary of *Gaviæ*.

Mr. J. H. Gurney (*loc. cit.* p. 40) mentions Herring Gulls of 44 and 21 years, Lesser Black-backed Gulls of 30 and 32 years, and a Great Skua of 24 years. The highest figures on my list are a Black-headed and a Jameson's Gull, each of over 21 years' duration—and a Yellow-legged Herring Gull of over 19 years' duration. Within the divisions there is no apparent correlation between size and either maximum or average durations. The Skuas and Terns lived on an average under 2 years, most of the Gulls more than 4 years. The Gulls were kept, during the period covered, in out-door aviaries, or if they were pinioned, in open paddocks. The alimentary tract of all the *Gaviæ* is relatively long and of narrow calibre: the cæca and hind-gut are very short and uncapacious except in the Skuas, when they are of moderate length. The group, in proportion to its size, shows only moderate longevity and viability.

Capt. Flower's only high record is that of a Lesser Black-backed Gull alive after 11 years' duration.

TUBINARÆ.

PUFFINIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Puffinus</i> , whole genus	6	1·6	4
<i>P. anglorum</i> (Manx Shearwater)	3	2	4
<i>P. kuhli</i> (Cinereous Puffin)	2	1	1
<i>P. major</i> (Greater Shearwater)	1	1	1
<i>Fulmarus glacialis</i> (Fulmar)	4	10	38

I do not know of any published information as to the longevity of the Tubinares, and the fate of the few examples on my list is only sufficient to show that they have very bad lives in captivity.

PYGOPODES.

COLYMBIDÆ.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tachybaptus fluvialis</i> (Little Grebe)	10	10·3	50
<i>Aechmophorus major</i> (Great ")	1	9	9
<i>Podiceps cristatus</i> (Crested ")	3	4·3	11
<i>P. griseigena</i> (Red-necked ")	1	1	1
<i>Colymbus arcticus</i> (Black-throated Diver)	1	1	1
<i>C. glacialis</i> (Great Northern ")	2	5·5	10
<i>C. septentrionalis</i> (Red-throated ")	6	5	12

ALCIDÆ.

<i>Alca torda</i> (Razorbill)	12	9	54
<i>Lomvia troile</i> (Common Guillemot)	33	6	52
<i>Uria grylle</i> (Black ")	6	1	2
<i>Fratercula arctica</i> (Puffin)	11	5	16

In the case of this group also, I do not know of published information. The records I can give are very bad; of 86 examples the average duration is under a year, and in most cases much under a year, whilst the figures would have been still worse if I had included a considerable number of Little Grebes, Crested Grebes, Razorbills, and Puffins that failed to live a month. In all these birds the intestinal tract is of moderate length, in proportion to size; even in the Divers the cæca and hind-gut are uncapacious, whilst in the others they are vestigial. I am unaware of anything in the structure of these birds from which we might infer a constitutional lack of viability as compared with, for instance, Gulls, and the conditions under which the attempt has been made to keep them are similar. I think that their lack of viability in captivity must be partly psychological, and to be referred to the set of causes which lower the average duration in captivity of most of the familiar mammals and birds of Europe.

IMPENNES.

	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Aptenodytes pennanti</i> (King Penguin)	9	3·6	11
<i>Pygosceles tenuatus</i> (Gentoo ")	8	2·5	7
<i>Spheniscus</i> , whole genus	29	17·5	135
<i>S. demersus</i> (Black-footed Penguin)	24	20	135
<i>S. humboldti</i> (Humboldt's ")	2	5	9
<i>S. magellanicus</i> (Jackass ")	3	5	8
<i>Eudyptes</i> , whole genus	16	13·5	88
<i>E. antipodum</i> (Yellow-crowned Penguin)	2	6·5	12
<i>E. chrysocome</i> (Rock-hopper ")	6	12	58
<i>E. pachyrhynchus</i> (Wide-beaked ")	5	4	8
<i>E. sclateri</i> (Selater's ")	3	37	88

In this group also I am unaware of published figures as to longevity. To the maximum of over 11 years' duration in the case of a Black-footed Penguin, I am able to add that of another example of the same species, now alive in the Gardens after a duration of $12\frac{1}{2}$ years, whilst there are several of over 6 years. The average duration shewn by the records is bad, in all cases under two years, in most under one. Penguins have an excessively long and slender alimentary tract, but the hind-gut and cæca are vestigial. In the period under consideration they were kept for the most part in a house with artificial heat and without access to fresh air, but some of the larger forms had free access to open air and they were by no means the most successful. I think it must be inferred that these birds have a good potential longevity, but that their viability in captivity, at least, is low.

CRYPTURI.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Tinamus solitarius</i> (Solitary Tinamou).	6	30	78
<i>Crypturus</i> , whole genus	24	12·7	66
<i>C. noctivagus</i> (Banded Tinamou) ...	10	13·4	45
<i>C. obsoletus</i> (Obsolete ") ...	4	1·7	4
<i>C. tataupa</i> (Tataupa ") ...	9	17	66
<i>C. undulatus</i> (Undulated ") ...	1	6	6
<i>Rhynchotus perdicarius</i> (Chilian Tinamou).	2	24·5	26
<i>R. rufescens</i> (Rufous Tinamou)	66	19·6	102
<i>Nothura maculosa</i> (Spotted Tinamou)	48	12	35

In the case of Tinamous, once more I am unaware of the existence of published records as to longevity. The maximum duration of $8\frac{1}{2}$ years (in the case of a Rufous Tinamou) and the average durations, which in most cases are under 2 years, show that these birds are rather less viable than the Guans, with which they may be compared in size and to some extent in habits. They have been kept under similar conditions—in an aviary with warmed shelters and open-air compartments. The structure of the alimentary canal differs from that of Gallinaceous birds chiefly in the relative shortness and want of capacity of the whole tract and in the much greater relative capacity and length of hind-gut and cæca.

APTERYGES.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Apteryx</i> , whole genus	22	48	240
<i>A. australis</i> (Kiwi)	1	97	97
<i>A. haasti</i> (Haast's Kiwi)	2	55·5	46
<i>A. mantelli</i> (Mantell's ")	9	50·5	240
<i>A. oweni</i> (Owen's ")	10	38·8	117

Mr. J. H. Gurney (*loc. cit.* p. 40) records an Australian Apteryx which died after having lived 20 years in our Gardens; this is

probably the same specimen recorded in my list as a Mantell's Apteryx. Although the Kiwis are small if considered in comparison with Struthious birds, they are actually large birds, and the figures of maximum and average durations cannot be taken as showing that these birds have a high viability in proportion to their size. They are nocturnal, and have generally been confined in small shelters in a heated aviary. The alimentary tract is of slender calibre, and not long in proportion to the size of the bird, but the hind-gut and especially the caeca are extremely capacious.

CASUARIÆ.*	No. of Indiv.	Average duration in months.	Maximum duration in months.
<i>Casuarius</i> , whole genus	72	30.8	186
<i>C. casuarius</i> (Common or Ceram Cassowary).	11	31	110
<i>C. c. beccarii</i> (Beccari's Cassowary) ...	7	16	24
<i>C. c. sclateri</i> (D'Albertis' ") ...	1	20	20
<i>C. c. salvadori</i> (Salvadori's ") ...	5	22.5	61
<i>C. c. intensus</i> (Blue-necked ") ...	4	17	29
<i>C. c. violicollis</i> (Violet-necked Cassowary).	6	26	38
<i>C. c. australis</i> (Australian ")	5	64	186
<i>C. bicarunculatus</i> (Two-wattled Cassowary).	5	34	86
<i>C. uniappendiculatus</i> (One-wattled Cassowary).	10	13.9	43
<i>C. u. occipitalis</i> (Jobi Island One- wattled Cassowary).	1	10	10
<i>C. u. aurantiacus</i> (Eastern One- wattled Cassowary).	1	8	8
<i>C. u. rufotinctus</i> (Red-tinted One- wattled Cassowary).	2	21.5	26
<i>C. philipi</i> (Sclater's ")	1	31	31
<i>C. papuanus</i> (Westermann's ")	5	45	85
<i>C. p. edwardsi</i> (Milne-Edwards's Cassowary).	2	14	15
<i>C. picticollis</i> (Painted-necked ")	1	29	29
<i>C. bennetti</i> (Mooruk)	5	78	174
<i>Dromæus novæ-hollandiæ</i> (Emu) ...	5	13.4	29

Mr. J. H. Gurney (*loc. cit.* p. 40) has recorded an Emu of 28 years, and a Westermann's Cassowary of 26 years. The figures on my list are very much lower, the maximum duration being $15\frac{1}{2}$ years for a Cassowary. In the period considered they were kept in a warmed house with open-air yards, but to what extent they were allowed free access to the yards, I am unable to say. The figures

* [In the synonymy of the Cassowaries I have followed Mr. L. W. Rothschild, *Trans. Zool. Soc.* vol. xv. p. 109.]

of average duration vary, but these and the maximum durations both show that at least under the conditions of captivity, Cassowaries and Emus have a low viability in proportion to their size. It is interesting to notice that the Emus, although larger than most of the Cassowaries, appear to be less viable. In the section on Struthioness which follows I refer to the conditions of the alimentary tract of these birds.

STRUTHIONES.	No. of Indiv.	Av. dur. in months.	Max. dur. in months.
<i>Struthio camelus</i> (Ostrich)	25	15.4	56
<i>S. molybdophanes</i> (Somali Ostrich) ...	4	25	62
<i>Rhea americana</i> (Common Rhea) ...	51	15.5	80
<i>R. darwini</i> (Darwin's „) ...	6	9	12
<i>R. macrorhyncha</i> (Great-billed Rhea)	11	17.6	43

Metchnikoff (*op. cit.* p. 78) has collected some information as to the longevity of Ostriches and their allies, and has come to the conclusion that 35 years would be an extreme age to be attained by these gigantic birds. The figures on my list show much shorter maximum durations, whilst the figures of average duration are still lower. It is interesting to note, that taking Kiwis, Cassowaries, Emus, Rheas, and Ostriches together, not only is there no direct correlation between size and average and maximum durations, but the familiar relation is reversed. The smallest birds, the Kiwis, according to my tables, show the highest viability; next come the Cassowaries, whilst the Ostriches, much the largest birds, are lowest. In the Kiwi and Cassowary, the cæca and hind-gut, although moderately capacious, are not specially so in proportion to the remainder of the alimentary tract; whilst in the Rheas, Emus, and above all in the Ostrich, the hind-gut and cæca are relatively enormously long and capacious, out of all proportion to the condition in any other group of birds and recalling the structure of herbivorous mammals. In their case there is the maximum opportunity for intestinal putrefaction, and these large Struthious birds, in proportion to their size, appear to have the lowest viability of all birds. Capt. Flower's only high record is an Ostrich alive after 12 years' duration.

SUMMARY OF AVES.

Constitutional differences in Longevity.

Putting together the information so carefully collected by Mr. Gurney, which of course related to maximum durations and potential longevity, and the results which I record here, we can draw the conclusion that very real constitutional differences in viability and longevity exist amongst the different families of birds. The chief difficulty is to distinguish between low viability due to special conditions of captivity and constitutional

low viability. It cannot be supposed that birds which are resident in Europe, or in England, have a lower constitutional viability than their congeners in more distant parts of the world, and yet, if we were to form conclusions as to the viability of such birds (or mammals) from the evidence given by captive examples, we should have to assign to them a very low position. So also insectivorous birds have usually a low viability in captivity, but this may well be due to the difficulty of providing them with suitable food. So also, if we were limited to knowledge of parrots under the usual conditions of a Parrot-house, we should have a very erroneous view of their potentialities.

Passerine birds are long-lived and hardy. Almost all of them have a potential longevity probably well over 20 years, and some of the larger forms may reach to over 60 years. The least hardy in captivity are Warblers, Tits, Pipits, Wagtails, Bulbuls, Orioles, Tanagers, and Larks. Tyrants, Bell-birds, and so forth, which are generally regarded as a lower grade of Passerines, appear less viable and shorter-lived.

Of Picarian birds, Colies, Hornbills, Motmots, Toucans, and Barbets have potential longevity approaching those of Passerines, but markedly lower, whilst their viabilities are relatively good; Woodpeckers, Kingfishers, Hoopoes, Bee-eaters, Rollers, Frogmouths, Cuckoos, and Touracous have much lower potential longevity and are less hardy. Owls have a potential longevity certainly extending to over 50 years, but their viability appears to be constitutionally low, their short average durations in captivity not depending altogether on any specially unfavourable conditions.

Parrots have a high potential longevity, certainly ranging well over 50 years. Their viability is almost certainly good, and their low average durations must be assigned to unfavourable conditions in captivity.

Diurnal birds of prey have potential longevity probably exceeding those of parrots. Their viabilities are better than those of Owls, the conditions in captivity being in neither case satisfactory.

Steganopodes have potential longevity ranging up to about 50 years, with very good viability; there seems no constitutional reason to assign a low viability to Gannets and Cormorants, and their treatment in captivity does not differ much from that of Pelicans. The actual figures show that they have had much lower average and maximum durations than Pelicans, but this most probably is to be associated with the failure in the case of many other European birds.

Hérons, Storks, Spoonbills and Ibises appear to have a potential longevity of over 30 years, and a fairly good viability. Ibises appear to have a better viability than the other members of the group.

Flamingoes have a potential longevity certainly considerably over 20 years, and have a high viability in captivity.

Screamers appear to have rather low potential longevity and viability, certainly much lower than those of Flamingoes or Geese.

Swans, Ducks, and Geese have a longevity most probably going beyond 50 years, and appear to have a good viability.

Doves and Pigeons have a potential longevity certainly reaching to about 30 years and have a very good viability.

Sand-grouse apparently are considerably lower than Pigeons both in potential and average duration.

Gallinaceous birds have a potential longevity ranging about 20 years, and only a fair viability. Megapodes, Curassows, and Guans seem to be most hardy and the longest lived.

The Hemipodes have considerably lower potential longevity and viability than Gallinaceous birds of about the same size.

Rails, Crakes, Porphyrios, and Gallinules appear to have potential longevities of not more than about 20 years, and have relatively low viability.

Of the Alectorides, Cranes have a potential longevity almost certainly exceeding 50 years and a very good viability. Kagus have a still better viability and probably a somewhat similar potential longevity. Bustards are the lowest of the group both in longevity and viability.

Limicolous birds have a potential longevity which is high in proportion to their size and must be set down as at least about 30 years. Either their constitutional viability is low or the conditions of captivity are specially unfavourable to them.

Gulls and their allies certainly have a potential longevity of at least 30 years, but their viability, at least under the conditions of captivity, is relatively low.

Puffins, Divers, Guillemots, and so forth have so poor a viability in captivity that no conclusions can be drawn as to their potential longevity.

Penguins have a potential longevity of at least over 12 years, but their viability under the conditions of captivity, in the period covered by my records, is low.

Tinamous appear to have a low potential longevity, certainly not much over 12 years, and a relatively poor viability.

The potential longevity of Struthious birds is certainly under 50 years, and their viability is relatively low.

Longevity and Size.

A very summary inspection of the tables of figures I have given will show that for birds as a whole there is no constant relation between potential longevity and size. The correlation does not exist even if only size and actual longevity be taken. An Ostrich is much bigger than a Crow or a Parrot, and yet cannot

attain so great an age. Nor does the correlation exist between size and viability, for if the same sets of birds be compared, it will be seen that the average expectation of life is much better in the case of the smaller birds. If, instead of absolute correlation, relative correlation be considered, the case is more striking. An Ostrich must be several hundred times larger and heavier than many birds which could outlive it, and which on the average do outlive it. If the comparison between birds and mammals be taken, it is equally clear that, apart from such a case as that of the whale for which a very great age is assumed, and that of man, there are many birds with potential longevities equal to those of the longest-lived mammals. Moreover, if the two Classes be compared from the point of view of longevity in proportion to size, the result is still more striking. On the whole, group by group, mammals are much larger than birds, herbivorous mammals than herbivorous birds, frugivorous mammals than frugivorous birds, omnivorous or carnivorous mammals than omnivorous or carnivorous birds. And yet, group by group, if the figures be compared, it becomes more and more obvious that birds approach and often surpass mammals in longevity and viability. Metchnikoff has already called attention to this difference and has associated it with the anatomical fact that the most striking difference between the alimentary tracts of mammals and birds is in the greater relative length, complexity and capacity of the hind-gut in the former group. The facts that mammals with relatively reduced and uncapacious hind-guts and cæca (such as the Carnivora) tend to have longer lives in proportion to their size, and that birds like the Struthious birds, which have relatively long and capacious hind-guts and cæca, have short lives in proportion to their size, still further confirm and support Metchnikoff's general proposition.

Within certain groups of birds the correlation between size and potential longevity appears to exist. It can be traced with more or less clearness in the case of Eagles, Owls, Passeres, and Picarian birds. But even in this limited fashion it is far from being universal. Probably Swans have a higher longevity than Ducks and Geese, but I cannot find any similar differences if Geese and Ducks be compared. Kagus appear to live as long as Cranes, Ibises better than Storks or Herons: there is no trace of the correlation in the case of Rails, or Pigeons or Gulls, and amongst Struthious birds the conditions are apparently reversed, and the Kiwi is hardier than the Ostrich.

I should hesitate to say that the differences in the constitutional longevities of birds could be associated universally with the structure of the alimentary canal, although there are some indications pointing in that direction. The Struthious birds and the Screamers have large and capacious hind-guts and cæca, and in proportion to their size have very short lives. Sand-grouse differ from Pigeons in having capacious cæca and have relatively

shorter lives. Owls have large cæca, Eagles and their allies have vestigial cæca, and Owls in proportion to their size appear to have lower potential and average longevities.

Many large birds such as Eagles, Vultures, Pelicans, Flamingoes, and Cranes, can attain great ages, but similar ages can be attained by much smaller birds such as Parrots and Crows. In proportion to their size, it is quite clear that Passeres have the longest potential and average durations; and that Parrots, Pigeons, and Limicolous birds, similarly in proportion to size, come next. There are few generalizations more difficult to support with convincing argument than those which relate to the relative degrees of specialization to be assigned to natural groups of animals, but I think that many ornithologists would agree with me if I were to say that Passeres, Parrots, Pigeons, and Limicolous birds were relatively high types, standing far away from whatever we may imagine the primitive bird-type to have been. And I think that the most certain general conclusion which I may draw regarding the relative longevity and viability of the groups of birds is, that in proportion to size, longevity and viability increase with perfection of organization. The further a bird has advanced along the lines of evolution of the bird group, the more viable it is. No doubt shortening of the hind-gut, reduction of the number of eggs in a clutch, increased care of the young, may all be taken as stages in the perfection of the bird-type, and so have a general association with increased longevity, apart from any direct influence which any one of them may have.

Viability, Temperature, and Open Air.

I cannot see that there is any relation between the climate from which birds come and their viability in captivity. Nor would such a relation be expected on general grounds, for birds, by their covering of feathers and the perfection of their vascular and respiratory systems, are well adapted to resist exposure to changes in temperature. If food be abundant, and if there be protection from draught, they seem remarkably indifferent to the temperature of the air. The interpretation, however, of their viabilities is obscured by special factors which existed in the period with which the figures deal, and which exist in most menageries. The comparison that is to be desired is a direct contrast between the viabilities of birds kept in the interior of a warmed house, and birds kept with little or no artificial heat and free exposure to the open air. The numbers of species and of individuals usually kept in captivity is much greater in the case of birds than in the case of mammals, and from the smaller size of birds and their more gregarious habits, it is usually possible to keep numbers of individuals of the same or of different species in the same aviary. The most familiar contrast in the conditions under which birds are kept, is that between one or two individuals in a small cage in

a warmed house, and considerable numbers of individuals in an aviary or enclosure giving room for exercise, and access to the open air. Now although many birds can be kept together, and are kept together, many casualties occur. A good deal of fighting and bullying takes place, and in practice, it is extraordinarily difficult to secure that every bird in the collection gets its due share of food, and is not worried by its messmates. Moreover, there is special danger of individuals which are affected by a communicable disease, or by parasites, infecting their healthy neighbours. Birds in separate cages avoid these evils; they are safe from bullying, they are properly fed, and if they are out of condition temporarily, have a chance of recovery. If we discount the very considerable advantage of protection that the Parrots obtained from their housing in separate cages, it will be seen from comparison of their average durations with their known high specific longevity, how poorly the device of keeping them in a heated house has answered. In a majority of cases, birds that have had free access to open air have lived in communities, and before judging of the advantage of fresh air, we have to discount the perils arising from their communal life. With these limitations and corrections, I think it is as clear an inference in the case of birds as in that of mammals, that making protection from temperature more important than the access to fresh air has failed in practice.

GENERAL SUMMARY.

(1) This memoir brings together the records of the duration of life in captivity of over 20,000 individual mammals and birds, and contains information which, so far as I can ascertain, has never before been set out systematically. The individual facts are imperfect, inasmuch as the sources did not record the age, or condition, of the individuals at the time of their reception in the Collection. The probable effect of these imperfections is to lower the figures both of average and of maximum duration. I hope to have shewn that from the point of view of exact knowledge and for practical reasons, it is important that those in charge of living animals should take steps to record such information as exactly as possible. Every individual should be observed for some time after its arrival, and the date when it is passed into the general collection as apparently in good condition should be recorded, whilst, if the exact age be unknown, it should be classified as infantile, adult, or aged. The houses, enclosures, or general conditions under which it is kept, with the date and nature of any changes of these, should be recorded. Finally the date, cause of death, and any further notes as to age should be entered. With such a system, in course of time, very exact conclusions could be obtained as to the viability and longevity of different kinds of animals, and as to the effect of the modes of keeping them in captivity.

(2) Following Ray Lankester, I distinguish between potential

longevity*, the limit of age which an individual could attain in the most favourable circumstances, and average or specific longevity, the average age to which the animals of a species attain under the natural conditions to which the species has become adapted. The difference between these two, I suggest is a measure of the severity of the conditions to which the species is subjected. In the case of the vast majority of animals it is impossible to get information as to either average or potential longevity. What information we have, is derived chiefly from knowledge of animals in captivity, and in this memoir I have been able to set down further information about species which have already been discussed by J. H. Gurney, Metchnikoff, Brehm and others, and to add information regarding many species about which nothing has been recorded hitherto.

(3) I apply the principle of comparison between average and potential longevity to the case of animals in captivity, by discussing the meaning of average duration and maximum duration. I suggest that a measure of the effect of the conditions to which animals are subjected in captivity may be obtained by comparison of the maximum duration with what may be known from other sources of the potential longevity, and by comparison of the average duration with the maximum duration. If the individual facts were collected in such a fashion as I have suggested in paragraph 1 of this general summary, I think the new method would lead to incontrovertible results, but even with the facts at my disposal, conclusions of fair validity can be drawn. It is necessary to note, however, that the figures of individual duration could be used to reveal more, if they were plotted out in curves instead of being used to give an arithmetical mean. The grouping of the individual cases with regard to the mean is of great practical importance. In some cases, for instance, I have pointed out that the majority of the cases were grouped towards the two extremes, that the individuals for the most part either

* [Lankester (*t. c.* p. 27) pointed out that some organisms, such as fish, molluscs, large crustacea, sea-corals, and many trees, appear to have no fixed potential longevity but to persist until they perish from disease, or are overwhelmed by some accident, whilst others, such as man, appear to have a set period to the possible duration of their lives. The mammals and birds with which I am concerned in this memoir belong to the second category. But I doubt if there be a fundamental distinction between the categories. First, as Lankester stated, the individuality of an organism like a tree, or a colonial invertebrate, differs from that of most organisms, and must be separately considered from the point of view of potential longevity. Next, certain organisms, such as many fish, appear to have more indefinite limits of growth (possibly related to mechanical factors, of similar importance in the case of aquatic mammals such as the Cetacea) than the majority of animals, the adult dimensions of which vary within narrow limits; definite or indefinite potential longevity may be related with definite or indefinite growth. (See also H. Spencer, 'Principles of Biology,' revised edition, 1898, vol. i. p. 135). I am more inclined to suppose that potential longevity varies with structure in the widest sense, including under the term structure the consequences of wear and tear, and auto-poisoning from the slow accumulation of waste-products. All pieces of machinery, from a motor-car to a cork-screw, have a potential longevity, dependent in the main on their structure, and apart from the quality of their manufacture, varying fairly closely with their complexity. Although our attention is arrested by extreme cases, these are only terms in a series.]

died in the first few months after arrival (by birth or otherwise) or survived to an age approaching the maximum, whilst in other cases there was a mortality rate steadily increasing with the length of residence in captivity. Obviously, the different curves that would be displayed by different animals, if the individual cases were plotted out in such a fashion, would give valuable information as to the special periods of danger in the case of different animals, and inform us if there were cases where the mortality was the result of progressive and cumulative effects of captivity. As, however, the facts at my disposal did not include any information as to the age or condition of the animals on reception, I came to the conclusion that it would be a waste of time to plot out curves.

(4) Unfortunately, collections of animals have to be considered from the financial point of view. The money value of an animal to a collection, that is to say, the price which can be judiciously paid for it, depends on its rarity, its attractiveness to the popular and scientific clients of the institution, and on the length of time it may be expected to live. A gorilla, for instance, is rarer and much more attractive than a chimpanzee, but as a gorilla has a very much worse expectation of life in captivity than a chimpanzee, its money value may be smaller. The facts that I have brought together form, so far as I know, the first beginning of a practical guide to the value of animals considered from this point of view.

(5) I have been able to bring together a large series of facts with regard to the relation between size and longevity. Taken in the broadest way, it is true that large animals may be expected to live longer than small animals, and in the case of very closely allied creatures the relation is frequently close. This may be associated partly with the effects of the accumulation of waste products. The cubical capacity of an animal increases much more rapidly than its linear dimensions, and of two animals of similar structure and constitution, the larger may take longer to be poisoned by its own waste products. Of course many simpler factors are involved—such as the greater resistance of a more bulky animal to rapid changes in the temperature of the air or water in which it lives. On the other hand, difference in longevity is not in exact proportion to size, and other constitutional factors are more important. Birds, for instance, in proportion to size, have higher potential longevities than mammals; whilst within the classes, orders, and even families, there are many cases where difference in size is overborne by other constitutional differences. It seems to be the case that, in proportion to their size, the more highly developed members of a group are able to live longer than their lower kin. There are also a very large number of cases, where increased viability and longevity are associated, as Metchnikoff suggested, with a relatively low capacity of the hind-gut.

(6) It has long been known to aviculturists that common

British birds are often very difficult to keep in captivity. I have shown that this difficulty occurs in so large a number of different kinds of British birds and mammals, that it may be laid down as a curious principle (to which naturally some exceptions exist) that British birds and mammals have a lower viability in captivity in England than their immediate allies from any other part of the world. This remarkable circumstance is in the first place, in the strict sense of the word, accidental, and finds partial explanation in a cause independent of the constitution of the animals. Most captured examples of wild species either are weakly individuals, or are injured or frightened by the process of capture: a heavy mortality is to be expected. In the case of animals that come from a distance, much of the heavy mortality takes place before arrival or, because of the additional evil effects of the conditions during transit, and the survivors which reach their destination are relatively strong and hardy. On the other hand, local animals reach their destination in a shorter time, and the heavy mortality takes place inside the Gardens. But this explanation is not wholly sufficient to cover the cases, and I think it may be assumed that wild birds and mammals in Britain have acquired an intolerance of man, without which, unfortunately, they would not have been allowed to maintain their existence. This psychological acquisition presses heavily on them in captivity. It appears to be the case that an opposite process of selection is taking place in the parks of great cities, and that wild birds in particular are learning not to fear man. It would be interesting to know if wild birds taken in a London park lived better in captivity than birds of the same species from country districts.

(7) The climate from which a bird or mammal comes has the smallest possible relation to its viability in captivity. A. Heilprin (*Distribution of Animals*, Int. Sci. Series, vol. lviii., 1887, p. 35) pointed out the error of the common belief as to climate being the principal factor that regulates or controls the distribution of animals. Amongst mammals and birds a vast majority of species and genera regarded as tropical have an actual or recent range into temperate or even frigid climates. Of those now limited to the tropics, still fewer are accustomed to a steady temperature. Some range periodically or occasionally to altitudes where great cold occurs; others, by exposure to the intense radiation of the dry air of plains at night, regularly endure cold going down to freezing-point; whilst many inhabitants of tropical forests (which we naturally associate with steamy heat) must be subjected to great cold in their nocturnal wanderings on the summits of tall trees. The abundance of thick hair and fur and of close feathering amongst tropical creatures is a clear indication that their life is not spent basking in tropical sunlight. Mammals and birds have the power of maintaining their internal temperature at a normal that varies only within an extremely narrow range, notwithstanding the temperature changes in their environment; and I do not doubt, not only that they can endure considerable

cold, but that even rapid and considerable changes of temperature are a necessary stimulus to their viability.

On the other hand, there are cases where the change to the climate of London is certainly trying, but these occur not amongst tropical but temperate or arctic animals. The production of a thick coat against the onset of winter cold, and its doffing when summer approaches, appear not to be direct reactions to temperature but organic rhythms adapted to the seasons in the natural habitat of the animals. Thus animals from the far North, accustomed to the short arctic summer, retain their thick coats in this climate long after their possession is cumbersome. Still worse is the case of animals brought from South temperate zones, which begin to moult their thick coats when our winter, their summer, approaches. I have not information as to how soon if ever these rhythms readjust themselves to the reversed conditions. It is clear, on the other hand, that part at least of the mechanism by which coats become warmer, is direct stimulation from the surrounding temperature, and such different creatures as Carnivora and Baboons rapidly get better coats when exposed to the open air. The seasonal rhythms connected with breeding are also a cause of mortality to young or adults, when the conditions of climate are reversed. Birds from the Southern hemisphere, if they survive, appear to readjust themselves in this respect; it is more doubtful if mammals do so.

(8) The idea that it is a fundamental necessity to protect healthy adult mammals and birds from cold by providing them with artificial heat is fallacious. The supreme necessity is free access to open air. In most cases this should be combined with shelter from rain and wind, and in some cases the shelter should be supplied with artificial heat—perhaps often even in excess of what is now customary—but only so far as it can be arranged without any detriment to fresh air. I think this is probably specially important in the case of nocturnal animals; as we are accustomed to see these asleep all day in the warmest corner given them, we are disposed to forget that at night they move about actively often in great cold.

For all mammals and birds steady exposure to an even temperature is unnatural and unhealthy; change is a necessary stimulus, and permanent existence indoors is the worst possible condition for viability and longevity.*

* [When this memoir was read my friend Dr. Leiper called my attention to the undoubted fact that the problem of the duration of life of animals in captivity is complicated by the effects of parasites. In the course of my paper (see pp. 470 and 540) I have made reference to this subject, pointing out that some of the evil caused by confinement in warmed houses is undoubtedly not the direct result of absence of fresh air, or of artificial heat, but comes about mediately inasmuch as the conditions are specially favourable to parasites. It is true of course that any argument as to the potential longevity of animals based on maximum durations in captivity is subject to the effects of parasitism. I hope that the work of Mr. Plimmer, Mr. Beddard, Dr. Leiper, Dr. Nicoll, and Mr. Coventry, who are now systematically examining the parasites at the Gardens, will before long enable us to eliminate some at least of these evils.]

(9) The tabulation and analysis of the records in this memoir has been a laborious task which has not been lightened by the knowledge that the materials were imperfect. But I trust that it may be a step towards obtaining systematic and more exact knowledge on the subject. Such knowledge is the only sure basis for that improvement in the condition of animals in captivity which those in control of Zoological Collections desire to bring about. The peculiarity by which a menagerie is distinguished from a museum is that its zoological specimens are alive. Not the obtaining of rare animals, nor the addition to the records of "species new to the Collection" should be the chief glory of a Zoological Society, but that Collection should be judged most valuable and successful in which the average duration of life of its inhabitants approaches potential duration most closely.

NOTE ON THE THEORY OF LONGEVITY.

With three notable exceptions, those of Lankester, Weismann, and Metchnikoff, discussions of the theory of longevity may be dismissed briefly here, partly because they have been treated fully in the literature of the subject*, and partly because they do not pretend to explain why the gift of life has been measured out to different animals in unequal portions. Bacon made a careful summary of the known facts, but refrained from general conclusions. "In tame creatures" he wrote, as cited by Lankester from Basil Montagu's translation, "their degenerate life corrupteth them, in wild creatures their exposing to all weathers often intercepteth them; neither do those things which may seem concomitants give any furtherance to this information (the greatness of their bodies, their time of bearing in the womb, the number of their young ones, the time of their growth, and the rest), in regard that these things are intermixed, and sometimes they concur, sometimes they sever." Buffon thought that there was a relation between the total duration of life and the period of growth, and set down the ratio between the two as 6 or 7 to 1. Flourens followed Buffon's idea, but took as the limit of growth, the age at which the long bones unite with their epiphyses, estimating that the ratio of the longevity to the period of growth was as 5 to 1. Bunge, without calculating an exact ratio, pointed out that there was a frequent relation between the longevity and the time taken by a new born animal to double its weight. Such calculations at the best are limited in their application to the higher animals, and even amongst these have to encounter many exceptions; so far as they go they must be taken as secondary and comparatively accidental correlations.

Ray Lankester's early contribution (*t. c.* p. 71) was a serious

* See specially E. Ray Lankester, *t. c.*; E. Metchnikoff, *t. c.* p. 39, and article *Longevity*, in the XI. edition of the *Encyclopædia Britannica*.

addition to knowledge. Having distinguished between potential and average specific longevities, and shown that the latter were determined to a large extent by accidents outside the constitution of the species (destruction by enemies, diseases and so forth), he attributed the former to constitutional causes of which the most important were the degrees of evolution or individuation and the amounts of personal and generative expenditure. High individuation, and low expenditure were to be associated with great potential longevity.

A. Weismann, in his famous essay *Ueber das Dauer des Lebens* (translated in *Essays upon Heredity*, Oxford 1889), examined the various constitutional explanations of the duration of life. He admitted that small animals might be expected to run through the cycle of life more rapidly than large animals; that if the period of growth were long it might expand the total duration of life; that creatures in which the metabolic processes were extremely active, might finish their career more quickly (as Lotze suggested in his *Microcosmus*) than slow-living creatures; that the rates of personal and of reproductive expenditure had some influence. But he urged that the application of these various principles was only partial and led to so many inconsistencies that no constant correlation could be established. He came to the conclusion that duration of life was really dependent upon adaptation to external conditions, that its length was governed by the needs of the species and was regulated by the same process as that by which the structure and the other functions of an organism were adapted to the environment.

In adaptation to the environment, Weismann urged, it is the prosperity of the species and not that of the individual that is concerned. That species is most successful which contains at any time the largest number of vigorous adults, and as every organism in the vicissitudes of life becomes to a certain extent worn and dilapidated, it is not to the advantage of the species that individuals should live too long. As soon as the business of reproduction has been successfully accomplished, the advantage of an individual to the species is gone, and the sooner it disappears the better. Animals are in fact wound up to go for the requisite time, and no longer. The mechanism Weismann suggested was a limitation of the possible number of cell generations, admitting that this was hypothetical. The requisite length of time was determined by the reproductive habits of the animals. Slow breeding, for instance the production of a small number at a birth or in a season, long brood-care either embryonic or post-embryonic, and all the various circumstances by which an organism or pair of organisms require longer time to replace themselves by their younger and fresher children, stretched out the duration of life; whilst rapid reproduction, absence of brood-care and so forth, contracted it. By the process of natural selection the incidence of death was adapted to the needs of the species.

Obviously where there was a heavy incidence of death on the young, a longer life would be required to secure replacement of the parent by successfully reared young.

Weismann (*t. c.* p. 11) brought together a very remarkable and cogent series of cases showing that a constant correlation existed between the reproductive powers and the duration of life of the individuals of a species, and his theory has an extremely important place in the history of the subject. It is to be noted, however, that although he appreciated the probability that a very large number of deaths were due to external causes (enemies, diseases, accidents, untoward conditions) he did not explicitly work out the important relation to his theory of Lankester's distinction between average specific longevity and potential longevity. It is clear that if the duration of life be fixed by some internal cause such as the limitation of cell-reproduction, it must be the potential longevity and not the average specific longevity that is affected; but if the majority of animals perish from accidents from without, it is difficult to see how their potential longevity could be influenced by selection.

Metchnikoff's most interesting work has still further increased the difficulty in the way of accepting Weismann's theory. Metchnikoff investigated the causes of death in a very large number of cases, including those of insects which die very soon after having laid their eggs, and came to the conclusion that it is extremely doubtful if natural death occurs except in the rarest possible cases. Most animals perish long before they have reached an age at all approaching what may be regarded as their potential longevity. In the cases that survive the accidents of youth or early maturity, another series of accidents take effect. The changes of senility are induced from without; the various degenerations are brought into existence by the absorption into the system of various kinds of poisons, and these whether they are due to the exudations of the microbes of intestinal putrefaction, or to those of special diseases, are entirely external to the constitution. Senile animals perish because they can no longer resist common diseases or common accidents. It would be only in a world where the most perfect hygiene reigned, and from which the bacteria and microbes of diseases had been driven, that the majority of the members of a species would attain the potential age, and that death would come on them from purely constitutional causes. And so the conception of the duration of animal life being an adaptation to breeding habits, produced by the operation of selection, disappears.

I cannot doubt but that the average specific longevity is the dominating factor in animal life. At every stage of their existence animals are assaulted from without by enemies, diseases, and their whole environment. To say that is merely to restate the existence of the struggle for existence, the fundamental proposition of the theory of natural selection. If favourable

variations arise, that is to say changes in diathesis, structure, function or habit, which enable the possessors of these to make a better fight against enemies, or diseases, or any part of their hostile environment, then we expect such variations to be preserved, and, consequently, the constitution of the organism to be modified in the direction of adaptation to its environment. It is no part of my present argument to discuss whether such variations appear in response to the environment, or by large or small stages; these are wide questions not germane to the present issue. But they do arise, and in such a fashion there have come about increases or decreases in size, advances in structure or degenerations, protective colours and weapons—the whole armoury offered by variation to the choice of natural selection. Such improved powers of resistance to the environment may increase the average specific longevity, and indirectly may affect the potential longevity. But the attainment of the latter is too rare an event to come under the direct control of natural selection.

There is no more important part of the structure and function of an organism than that associated with reproduction. The impulses and instincts connected with fertilization, the time, duration and frequency of rutting, the numbers of ova that are fertilized and allowed to develop, the duration of embryonic development, the amount and character of post-natal brood-care, the whole apparatus and machinery of the reproductive process, present an extraordinary series of modifications from species to species, and from individual to individual. They are subject to much variation amongst individuals at the present time, and it may well be presumed that they have offered a rich material to natural selection in the past. Weismann has established a correlation between longevity and reproduction, but I think his interpretation of the correlation must be reversed. It is not longevity that has become adapted to reproduction, but the rate of reproduction has been adapted not to potential longevity, but to average specific longevity. Average specific longevity is simply a measure of the pressure of conditions on a species, and its constitution, including its mode of reproduction, has been shaped in conformity with the pressure of these conditions. Potential longevity is a bye-product of the process; it depends directly on the constitution, and is simply the result of the fact that if the constitution be adapted to meet the average mortality, it must be able to outlive, and will outlive, the average duration of life in a number of fortunate cases.

25. Some new Parasitic Nematodes from Tropical Africa.

By ROBERT T. LEIPER, D.Sc., M.B., F.Z.S.

[Received April 4, 1911 : Read April 25, 1911.]

(Text-figures 140-144.)

In the following paper I give a brief description of a number of new genera that have recently come under my notice in the course of an examination of helminthic material collected by me during a visit to East Africa, Uganda and the Soudan, whilst a member of the Egyptian Government Survey in 1907, and of further material sent to me at the London School of Tropical Medicine by members of the Colonial Medical Service.

NEMATODA.

Family ANCYLOSTOMIDÆ.

Genus ACHEILOSTOMA, gen. n.

Species SIMPSONI, sp. n. (Type sp.)

Host: a large rodent. Locality: Nigeria.

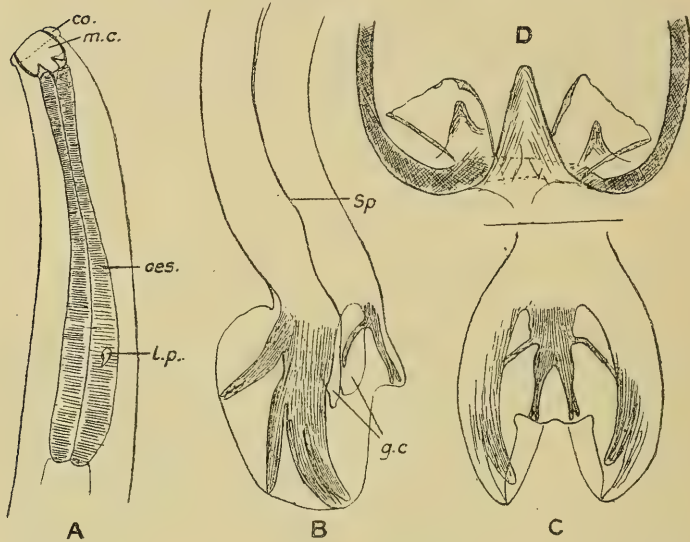
A large number of specimens was collected from the alimentary canal and preserved in 70 % alcohol. The males measure 17 mm. in length, the females 23 mm. in length. The former are less numerous than the latter. The cuticle shows marked transverse striation in the anterior end of the body. The individual striæ are so deeply cut as to give the edge of the cuticle in this region a serrated appearance. At a distance of 0·8 mm. from the anterior end are two large stout lateral papillæ curving backwards and shaped like large thorns (text-fig. 140, A, *l.p.* p. 550). The anterior end of the body is bent dorsally only very slightly, showing that the oral aperture, which is surrounded by a thick collar, 0·004 mm. deep, is almost but not quite terminal. The mouth capsule shows similar characters to those found in other members of this family. There is a large median ventral tooth and two fan-shaped inner teeth guarding the œsophageal entrance to the buccal capsule dorsally (text-fig. 140, D). The buccal capsule has a chitinous wall, and resembles that of *Necator* rather than that of *Ancylostomum*. The most striking feature of the genus, however, is the entire absence of teeth or cutting-plates guarding the entrance to the oral aperture. There is no indication either of a corona radiata; so that although the buccal cavity of the parasite recalls that of the Ancylostomes in its internal characters, the oral aperture reminds one rather of the Bunostomes.

The œsophagus measures 0·95 mm. in length and shows no special characters. In the female the genital pore lies almost at the centre of the body. The eggs in the uterus measure 0·055 mm. \times 0·032 mm. and usually contain a few segments.

In the male, the posterior end of the body is surrounded by a

well developed bursa that projects much more ventrally than dorsally (text-fig. 140, B). The genital cone (text-fig. 140, B, *g.c.*) is greatly developed and can be seen projecting between the two sides of the bursa and the dorsal membrane. The dorsal membrane is distinctly delimited from the lateral halves of the bursa and is very much shorter (text-fig. 140, C).

Text-fig. 140.

*Acheilostoma simpsoni.*

- A. Anterior extremity showing mouth capsule *m.c.*, oesophagus *oes.*, lateral cervical papilla *l.p.*
- B. Bursa of male, lateral view: *g.c.*, genital cone; *sp.*, spicules.
- C. Bursa showing division of dorsal ray.
- D. Base of mouth capsule showing chitinous folds of the wall of the capsule guarding the oesophageal orifice.

The dorsal ray is short and thick and bifurcates about halfway along its length to form two stout rays, which are again split into two subdivisions as they reach the edge of the bursal membrane. The externo-dorsal rays leave the dorsal ray from about the middle of the thick undivided portion. The ventral rays are fairly well developed and are united to their tips. All the lateral rays, middle and posterior, run to the bursal edge almost side by side, but the anterior ray, which has a thickness almost equal to the two central rays combined, takes a separate course, ending about one-third of the distance from the midlateral to the ventral rays. (Collected by J. J. Simpson, Esq.)

Family STRONGYLIDÆ.

Subfamily CYLICOSTOMINÆ.

Genus CYLINDROPHARYNX, gen. n.

Species BREVICAUDA, sp. n. (Type sp.)

Host: Zebra. Locality: British East Africa.

The Zebra is the subject of a considerable number of parasites that occur normally in the Horse, but in addition it appears to have found a few peculiar to itself. While examining a number of Cylicostominæ cleared in glycerine, I noticed a number of specimens that appeared to have an abnormally deep buccal capsule. The shape of this capsule struck me at once as of generic value, and on further search I was soon able to distinguish in the material two distinct species showing this special character.

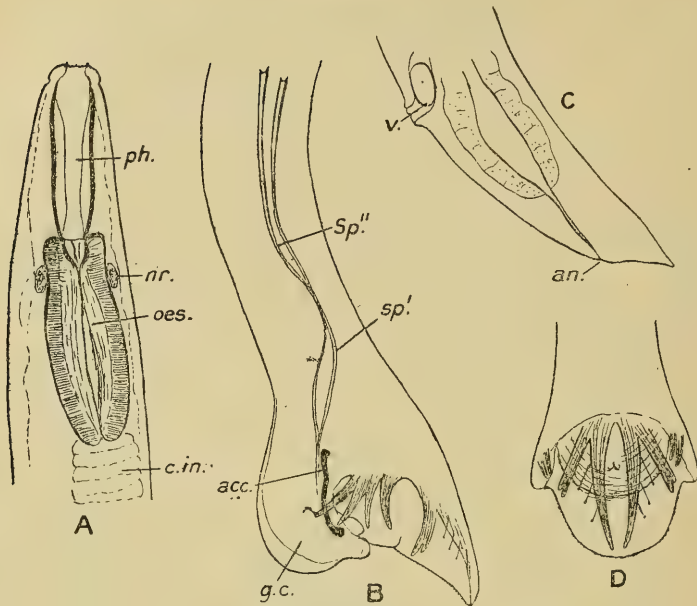
To the naked eye appearances the species of this genus resemble exactly those of *Cylicostomum*. The mouth is surrounded by a collar bearing a double corona radiata. In *C. brevicauda*, the type species, the buccal capsule is cylindrical, and has a thick chitinous wall measuring 0.4 mm. in depth and 0.1 mm. in transverse diameter. The œsophagus is exceedingly short and fleshy, measuring 0.46 mm. in length and 0.18 mm. in greatest diameter. The nerve-ring surrounds the œsophagus immediately behind its union with the buccal capsule (text-fig. 141, A, p. 552). In the female, the posterior end tapers very quickly from a diameter of 0.25 mm. at the level of the vulva to a pencil-like point. The vulva opens at 0.7 mm., the anus at 0.18 mm. from the extremity (text-fig. 141, C). In the male the bursa shows a characteristic disposition of the rays. The posterior ray is split to its base into two portions, and each of these is again split as far into an internal and external ray. The external ray is bifurcated as it reaches the edge of the bursal membrane (text-fig. 141, D). The genital cone is very large and protuberant. The spicules are long and filiform, measuring 1 mm. in length. There is a stout thick uneven accessory piece 0.2 mm. in length (text-fig. 141, B). The edge of the bursal membrane is finely serrated as in the genus *Triodontophorus*.

CYLINDROPHARYNX LONGICAUDA, sp. n.

Host: Zebra. Locality: British East Africa.

This species closely resembles *C. brevicauda*, but the buccal capsule is smaller, measuring only 0.23×0.07 mm. The œsophagus is more slender, measuring 0.42×0.12 mm. (text-fig. 142, A). In the female the tail is long and pointed. The vulva is situated much farther forward in this species, opening at 1.55 mm., whilst the anus opens 0.32 mm. from the posterior extremity (text-fig. 142, D). In the male the spicules are shorter, 0.7 mm. The accessory piece is less developed and shorter, 0.13 mm. The genital cone is more globular (text-fig. 142, B). The rays differ more particularly in that the external branch of the posterior is undivided (text-fig. 142, C). (Collected by Dr. J. T. C. Johnson.)

Text-fig. 141.

*Cyldropharynx brevicauda.*

- A. Anterior extremity showing deep cylindrical pharynx (*ph.*) and short muscular oesophagus (*oes.*), nerve-ring (*nr.*), and chyle intestine (*c.in.*).
 B. Bursa of male showing the long spicules (*sp.*'), (*sp.*'') and well-developed accessory piece (*acc.*). The externo-dorsal ray is bifurcated at its tip. There is a large protruding genital cone (*g.c.*).
 C. Posterior extremity of female showing relationship of vulva (*v.*) and anus (*an.*) to tip of tail.
 D. Dorsal rays of bursa as seen from ventral surface; the edge of the bursa is serrated.

Subfamily STRONGYLINÆ.

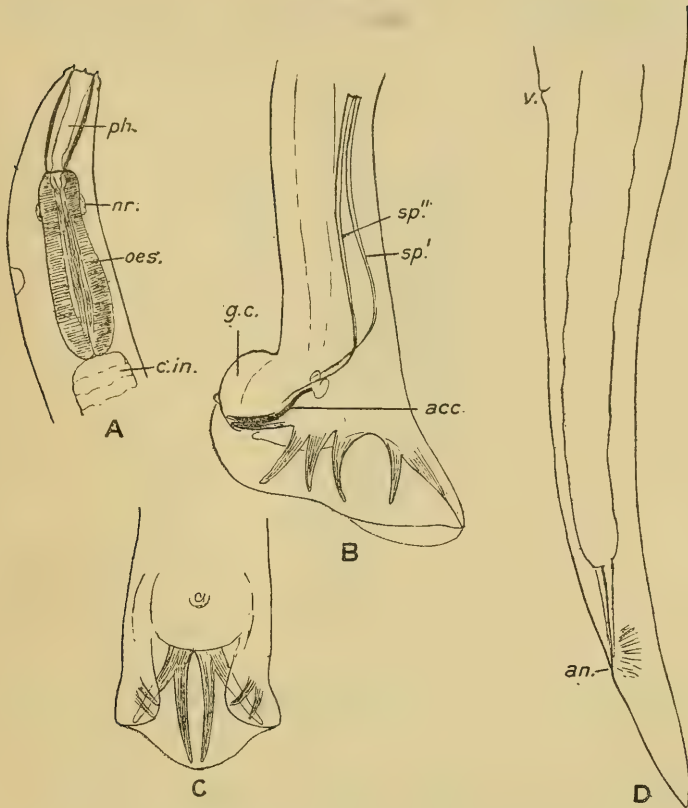
Genus TRACHYPHARYNX, gen. n.

Species NIGERLÆ, sp. n. (Type sp.)

Host: a large rodent. Locality: Nigeria.

Among the above specimens were a few shorter and more stumpy forms that on microscopical examination proved to belong to quite a different family. The specimens were few in number and badly preserved. The diagnosis is based upon the anterior end of the body, mainly because in both sexes the posterior end was obscured and embedded in a thick brown prostatic secretion. The males measure 11 mm. in length and the females 15 mm. in length, and 0.46 mm. in breadth. They taper a little at either end.

Text-fig. 142.

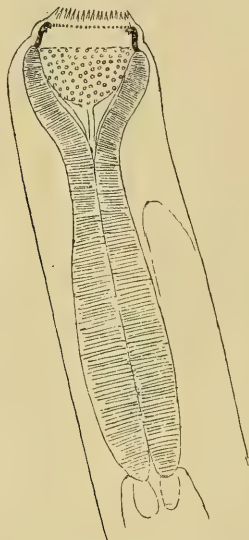
*Cylindropharynx longicauda.*

Explanation of individual figures as in text-fig. 141.

The oral aperture is quite terminal, and is surrounded by a well developed corona radiata highly reminiscent of that found in the species *Strongylus equinus*. The number of leaves in the external crown could not be determined exactly. The internal crown was distinctly visible as a series of comma-like projections, apparently corresponding in number to those of the external crown. The oral capsule is a wide pear-shaped cavity, the anterior third of which is surrounded by a thick wall of cuticle, the posterior two-thirds being almost entirely replaced by a layer of oesophageal musculature, which is however covered by a thin layer of cuticle bearing a large number of round cuticular knobs that project into the buccal cavity. The oesophagus measures 1.25 mm. from the base of the cuticular portion of the buccal capsule to its termination in the chyle intestine. Where

the œsophageal musculature supports and encloses the buccal cavity the muscular tissue is only 0·006 mm. in thickness, but in the posterior third the œsophageal musculature attains a thickness of 0·13 mm.

Text-fig. 143.



Trachypharynx nigeriæ.

Anterior extremity showing buccal capsule.

The females were full of eggs, and although the details of the posterior end of the body could not be made out exactly, the vulva appeared to be situated a short distance in front of the anus, which in turn was situated almost at the posterior end of the body. (Collected by J. J. Simpson, Esq.)

Family SPIROPTERIDÆ.

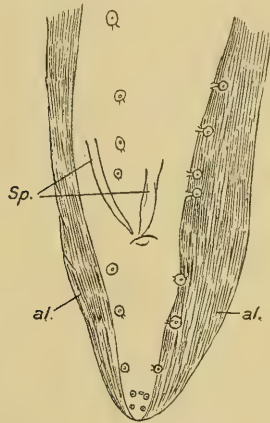
SPIROPTERA UGANDA, sp. n.

Host: Monkey. Locality: Uganda.

In the intestine of a Monkey a fragment of a male worm was found. The anterior portion, having been cut off in the process of opening the gut, was unfortunately lost. The essential points are, however, shown in text-fig. 144, which illustrates the posterior end, showing the papillæ and other specific characters. The papillæ are large, and arranged as four pairs of pedunculated preanals and five pairs of postanals, three of these being pedun-

culated, the terminal two pairs being sessile. On either side, the cuticle is expanded to form an alar ledge about 0.2 mm. in breadth. The expansions are marked on the ventral aspect by a longitudinal

Text-fig. 144.

*Spiroptera uganda.*

Posterior extremity of male: *al.*, alæ; *sp.*, spicules.

striation similar to that commonly found in other species of the genus *Spiroptera*. The spicules are remarkably short and almost equal, measuring 0.2 and 0.3 mm. in length respectively.

ADDENDUM.

COBBOLDINA nom. nov.

* for *Cobboldia* Leiper 1910, preocc.

In my memoir on the "Entozoa of the Hippopotamus" published in the Proceedings of the Zoological Society for 1910, at page 235, I described and figured a new genus *Cobboldia* having as type *Cobboldia vivipara*, sp. n.

Mr. Hassall and Dr. Schouteden have kindly drawn my attention to the fact that *Cobboldia* has been used already for a genus of Insects and is therefore not available. I propose to replace *Cobboldia* Leiper 1910, by the new generic name *Cobboldina*.

R. T. LEIPER, D.Sc., F.Z.S.

May 1911.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

March 21st, 1911.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of February 1911.

Mr. R. I. Pocock, F.Z.S., Superintendent of the Gardens, exhibited:—

(1) A pair of Otter cubs about seven weeks old, which were found under a landing-stage at Tewkesbury, and presented to the Society by Mr. W. Baring Bingham, F.Z.S.

(2) A specimen of the North American Black-footed Polecat (*Putorius nigripes*), recently received in exchange from the Zoological Society of Washington, a species furnishing, in Mr. Pocock's opinion, an admirable instance of "warning coloration."

(3) The skin of a Chacma Baboon (*Papio porcarius*), from Potchefstroom in the Transvaal, representing an apparently undescribed subspecies, for which the name *griseipes* was proposed, in allusion to the speckled coloration of the hands and feet, a character in which it differed markedly from the typical black-handed Chacmas of Cape Colony.

* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

(4) The frontlet and antlers of a specimen of the Manchurian Wapiti (*Cervus xanthopygus*), to show variation in the structure of the two antlers, one having a short "bez"-tine nearly midway between the "brow" and the "trez," the other a long "bez"-tine rising close to the "brow"-tine.

Mr. D. SETH-SMITH, F.Z.S., the Society's Curator of Birds, exhibited a living Hybrid Duck, which was believed to be a cross between the White-eyed Pochard (*Aythya nyroca*) and the Marbled Duck (*Marmaronetta angustirostris*). It was hatched at Scampston Hall, Yorkshire, from a clutch of eggs laid by a Marbled Duck at Lilford Hall, Northamptonshire. The bird displayed the characteristic markings of *Marmaronetta*, but the general colour was dark reddish brown. It had been presented to the Society by Mr. W. H. St. Quintin, F.Z.S.

Mrs. E. W. SEXTON presented a paper, communicated by Dr. W. T. CALMAN, F.Z.S., "On the Amphipod Genus *Leptocheirus*." In preparing this revision of the genus the type specimens of nearly all the species had been examined. The author found that in some cases different stages of growth had been described by different authors as distinct species, in other cases the inadequacy of the original descriptions and figures had led to the introduction of a number of unnecessary synonyms. The specimens of Zaddach's *L. pilosus* and Grube's *L. guttatus* had been examined and re-described, and the number of valid species in the genus was now seven, namely: *L. pilosus*, *L. pinguis*, *L. hirsutimanus*, *L. pectinatus*, *L. guttatus*, *L. aberrans*, and *L. bispinosus*.

MESSRS. J. LEWIS BONHOTE, M.A., F.L.S., F.Z.S., and F. W. SMALLEY, F.Z.S., read their paper on Inheritance of Colour in Pigeons, which dealt with the first results of a long series of experiments. Although chiefly Mendelian in character, the authors laid stress on the fact that in several respects their results seemed to point to a further law or laws, which were able to modify the expected Mendelian results and in regard to which the Mendelian theory offered no satisfactory solution. They showed, for instance, that in Chequer and Blue matings there was a regular tendency to an over-production of Chequers, in the Grizzle matings the tendency was to an over-production of Blues. Another point apparently inexplicable on the Mendelian hypothesis was the difference in shades of the same colour; by disregarding these and considering them all as gametically identical, the results gave approximately the expected proportions, but, on the other hand, the shades of the different birds undoubtedly affected their progeny, and hence the gametes must also have been affected. The preponderance of a certain sex in a particular colour was also noted, as well as an increase of white

in successive generations. No explanation of these phenomena was put forward, as further experiments were still in progress.

In dealing with the purely Mendelian aspect of the results the following points were clearly brought forward :—(1) Silver is dilute Blue. (2) Blue is dominant to Silver. (3) Chequering and Grizzling are both dominant to absence of pattern. (4) Grizzling is dominant to Chequering. (5) A Mealy is a Grizzled bird with the White replaced entirely or partially by Red. (6) Red in a Mealy is dominant to White, hence a Mealy is dominant to a Grizzle. (7) White and Grizzling combine to have a common inheritance. (8) Red combines with Grizzling in the same way as White.

Dr. G. STEWARDSON BRADY, M.D., F.R.S., C.M.Z.S., presented a paper on Marine Ostracoda from Madeira, based on specimens collected by the Rev. Canon Norman, F.R.S., in the spring of 1897. Apart from the species described as new to science, the collection was interesting as extending the known range of several species from the European and North Atlantic areas much farther southward, though not quite into the tropical zone.

The next Meeting of the Society for Scientific Business will be held on Tuesday, April 4th, 1911, at half-past Eight o'clock P.M., when the following communications will be made :—

1. Dr. R. T. LEIPER, F.Z.S.

Demonstration of Nematode Parasites obtained from Animals in the Gardens.

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—No. I. On some Mammalian Tapeworms.

2. J. A. MÖRCH.

On the Natural History of Whalebone Whales.

The following communications have been received:—

1. WILLIAM NICOLL, M.A., D.Sc., M.B., F.Z.S.

On Three new Trematodes from Reptiles.

2. Dr. R. W. SHUFELDT, C.M.Z.S.

On the Comparative Osteology of *Cercopithecus* and *Callithrix*
(*C. sabaeus* and *C. callitrichus* and *C. jacchus*).

Communications intended for the Scientific Meetings should
be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

March 28th, 1911.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

April 4th, 1911.

Dr. HENRY WOODWARD, F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

Dr. H. B. FANTHAM, F.Z.S., and Miss ANNIE PORTER, D.Sc., exhibited some diseased bees and combs infected with a minute pathogenic Protozoal parasite, apparently the same as *Nosema apis* found by Zander and Doflein in diseased bees in Bavaria. Microscopic preparations and drawings of the parasite, *Nosema apis*, were also shown, as well as healthy bees and combs in contrast. The material exhibited was obtained from Cambridge-shire and Hertfordshire in March 1911. The infected combs were brown in colour instead of the normal yellow, while the infected bees suffered from a sort of dry dysentery which rapidly proved fatal. The pathogenic agent of this dry dysentery, *Nosema apis*, formed thousands of minute spores which fouled the hive, while infection was probably spread to new hives by hungry, weakly bees attempting to enter healthy hives. The spores, about 2 to 3 μ by 4 to 6 μ , were the resistant and cross-infective stages of the Protozoön. The parasite *Nosema apis* was closely allied to that of pébrine, the silkworm disease due to *Nosema bombycis*. The trophozoite and pansporoblast stages of *N. apis* had been observed, as well as some spores with polar filaments extruded. Like *N. bombycis*, the bee-parasite was possibly capable of hereditary infection, as infected bee-larvæ had been found. The only certain destructive agent of the Microsporidian spores was fire, and all infected bees and hives, and any

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débris therefrom should be most carefully burned. In the opinion of the exhibitors, the Microsporidian parasite, *Nosema apis*, had been responsible for much of the bee-disease recorded in this country since 1906, especially in 1906, 1907, and 1911. The exhibitors first noticed the parasite in 1906 in diseased bees obtained from the Isle of Wight; its full significance was grasped in 1907, but owing to the difficulty of obtaining material the exhibitors' results were not published. As much attention was now being directed to "bee-disease," the exhibitors briefly recorded their observations. It was not asserted that microsporidiosis was the only disease of bees current in Great Britain at present, as Dr. Malden had investigated a bacillary infection in bees. Microsporidiosis had probably been introduced from the Continent into British apiaries.

Dr. R. T. LEIPER, F.Z.S., gave a demonstration of Nematode parasites obtained from animals in the Zoological Gardens during the year ending November 1910.

The collection contained a number of new forms, of which a systematic account will be published later. Among the more interesting of the known forms were *Rictularia plagiostoma* from a Palm-Civet, a number of species of *Polydelphis* from various Pythons, *Dicheilomena horrida* from the South American Ostrich, and *Dictyocaulus filaria* from the lungs of Sheep.

It was noticed that whereas intestinal parasites were almost wholly collected from animals that had not lived in the Gardens for more than six months, those of which the normal habitat and food were the internal tissues of the host occurred in animals that had been confined in the Gardens for several years. Thus, an undescribed *Filaria* was found in a Lemur after four years, and *Filaria australis* in a Wallaby after two and a half years' captivity.

In all these cases the number of parasites obtained was small, and could have had little or no effect upon the health of the host. There was a remarkable preponderance of female forms.

From these observations it appeared that the change of food and general conditions obtaining in the Gardens were unfavourable to the continued existence of the intestinal parasites an animal may harbour on its admission. The number of cases of auto- and re-infection during captivity was strikingly small, and bore testimony to the cleanly surroundings in which the animals were kept. In four cases only was there evidence of the occurrence of accumulative infection in the Gardens:—

1. A number of Giant Toads died from lung infection with *Rhabdias bufonis*.
2. The Wolves appeared to be heavily infected with *Ascaris canis*.
3. A Sheep died from pneumonic condition resulting from an intense infection with *Dictyocaulus filaria*.
4. The Tortoises had Oxyuriasis.

In all these cases repeated infection undoubtedly had followed from contamination of food and drink with faeces containing eggs of the parasite. The infection could be eliminated by steam sterilisation of the cages, or still more easily by changing the species of animal living in the particular paddocks or cages, for Helminthes were often peculiarly selective as regards their hosts, and those flourishing in one animal sometimes found it impossible to continue their life even in closely allied forms.

Sir E. RAY LANKESTER, K.C.B., F.R.S., F.Z.S., exhibited a special Supplement of the 'Field' newspaper dealing with the British non-migratory Trout, and called attention to this new medium for the publication of scientific observations requiring illustration.

The SECRETARY read a letter from the Governor of Seychelles, received through the Secretary of State for the Colonies, on the subject of the herd of Land-Tortoises at Government House, Mahé.

Mr. R. I. Pocock, F.L.S., F.Z.S., Superintendent of the Gardens, exhibited the body of a newly-born cub of the Masked Palm-Civet (*Paradoxurus larvatus*) from Szechuen, and after pointing out its differences from the adult, drew attention to a peculiar abnormality in the left foreleg.

Mr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, read a paper on some Mammalian Tapeworms which had been collected from animals that had died in the Society's Gardens. This collection was the result of nearly two years' examination of a very large number of animals, but did not contain a very large number of species. Tapeworms were by no means so common as other parasitic worms, particularly Nematodes, which were the most abundant among the animals in the Gardens.

Dr. S. F. HARMER, M.A., F.R.S., V.P.Z.S., communicated a paper by Mr. J. A. Mörch, of Christiania, on the Natural History of Whalebone Whales, drawing attention to, and throwing light upon, some of the problems connected with the migrations of the larger Cetacea.

The next Meeting of the Society for Scientific Business will be held on Tuesday, April 25th, 1911, at half-past Eight o'clock P.M., when the following communications will be made :—

1. MR. D. SETH-SMITH, F.Z.S.

Exhibition of Lantern-slides :—

- (a) Penguins in Moults.
- (b) Wild Swainson's Lorikeets.

2. DR. R. T. LEIPER, F.Z.S.

Some new Parasitic Nematodes from Tropical Africa.

3. DR. CUTHBERT CHRISTY, F.Z.S.

On a Collection of Antelope and other Skins from the Chagwe Forests, Uganda.

4. WILLIAM NICOLL, M.A., D.Sc., M.B., F.Z.S.

On Three new Trematodes from Reptiles.

The following paper has been received :—

H. W. MARETT-TIMS, M.D., F.Z.S.

Tooth-Germs in a Kangaroo.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

April 11th, 1911.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

April 25th, 1911.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of March 1911.

Mr. D. SETH-SMITH, F.Z.S. the Society's Curator of Birds, exhibited:—

(1) A nest of the Grey Struthidea or Apostle Bird (*Struthidea cinerea*), composed entirely of mud, and built on a branch in the Western Aviary.

(2) Lantern-slides from photographs of the King Penguin (*Aptenodytes pennanti*) and Black-footed Penguins (*Spheniscus demersus*) showing the method of moulting.

(3) Lantern-slides from photographs of a number of wild Swainson's Lorikeets (*Trichoglossus nove-hollandiae*), kindly sent by Mrs. Innes, of Mackay, North Queensland. These birds came in large numbers to feed daily at a table, on syrup provided, settling without fear upon the head, shoulders, and arms of the lady who fed them.

Mr. C. TATE REGAN, M.A., F.Z.S., exhibited a series of lantern-slides of scales of the Salmon (*Salmo salar*), and showed how the life-history of the fish could be read from its scales.

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Dr. WILLIAM NICOLL, M.A., F.Z.S., exhibited some preparations from a Hare which showed an interesting and unique pathological condition. The liver was extensively invaded with calcareous nodules which were due to a parasitic Nematode of the family *Trichotrachelidae*. The worms were so coiled up that they could not be extricated entire, but the ova, which were present in enormous numbers, showed that they must belong to a peculiar genus. The structure of the eggs was remarkable in displaying a double-layered shell, with a markedly papillated surface. No similar condition had been hitherto recorded from the Hare or Rabbit, but an analogous condition had been met with fairly frequently in Rats. It was still impossible to say whether the conditions in the two animals were caused by the same species of parasite, but experiments with a view to determining this were in progress. The Hare further showed a large infection with *Trichostrongylus retortaeformis*, and a slight, purely intestinal, infection with *Coccidium cuniculi*. There were also signs of recent parturition and of an inflammatory condition of the uterus. Whether this or the liver disease was the cause of death, which took place under remarkable circumstances, is doubtful.

Dr. CUTHBERT CHRISTY, F.Z.S., exhibited part of a collection of skins of mammals and reptiles obtained by him in Uganda, which included those of the Antelope, Leopard, Civet, Hyrax, &c., and drew attention to a rare form of *Dendrohyrax*, *D. emini*, and to the skin of a melanistic form of the Civet.

Dr. WILLIAM NICOLL, M.A., F.Z.S., read a paper on Three new Trematodes from Reptiles, from material received from the Society's Prosectorium. The specimens were interesting as forming an important addition to our knowledge of the large variety of forms which inhabited the air-passages and anterior coil of the alimentary canal of reptiles and batrachians.

Dr. R. T. LEIPER, M.B., F.Z.S., read a paper on some Parasitic Nematodes from Tropical Africa, and gave a brief description of a number of new genera. The paper was based on helminthic material he had collected during a visit to East Africa, Uganda, and the Soudan in 1907, and on material sent to him by members of the Colonial Medical Service.

Mr. OLDFIELD THOMAS, F.R.S., F.Z.S., read a paper, the fourteenth of the series, on Mammals collected in Southern Shen-si, Central China, by Mr. Malcolm Anderson, for the Duke of Bedford's Exploration of Eastern Asia. The region explored was in the Great Pe-ling (or Tsin-ling) range, that divides Northern from Southern China, many of the specimens coming from the sacred mountain Tai-peï-san, where several of the most interesting forms were obtained.

Of these by far the most striking was a new species of Takin (*Budorcas*), readily distinguishable by its uniform golden buffy colour from the Sze-chuen species (*B. tibetanus*). In the adult of this fine animal the coloration was wholly buffy, the darkening of the ears, dorsal line, hinder back and limbs found in *B. tibetanus* being absent, and there was scarcely a trace even of the dark facial patch so prominent in that animal. The new species was proposed to be called *Budorcas bedfordi*, and female no. 2190 was selected as the type.

Other new forms were as follows :—

ARCTONYX LEUCOLEMUS ORESTES, subsp. n.

Lighter than in true *leucolæmus*. Dark orbital patch reduced to a narrow rim round eye.

Head and body 570 mm.; tail 195; skull 132.

Hab. Tsin-ling Mts., alt. 12,000'. *Type.* Female. No. 2191.

MICROTUS CALAMORUM SUPERUS, subsp. n.

Rather larger and with decidedly longer tail than true *calamorum*.

Head and body 130 mm.; tail 63; hind foot 24; skull 33.

Hab. S. Shen-si. *Type.* Male. No. 2163.

OCHOTONA SYRINX, sp. n.

Near *O. cansa*, but larger. Bullæ smaller.

Head and body 142 mm.; hind foot 28·5; skull 36·5.

Hab. Tai-pei-san. *Type.* Male. No. 2170.

In all, the collection contained 160 specimens referable to 30 species.

The next Meeting of the Society for Scientific Business will be held on Tuesday, May 9th, 1911, at half-past Eight o'clock P.M., when the following communications will be made :—

1. R. I. Pocock, F.L.S., F.Z.S.

On the Palatability of some British Insects. (Experiments made in the Society's Gardens with Arthropods (chiefly Insects) and Molluscs, and Notes on the significance of Mimetic resemblances.)

2. Prof. GILBERT C. BOURNE, D.Sc., F.R.S., F.Z.S.

Contributions to the Morphology of the Group Neritoidea of Aspidobranch Gastropods.—Part II. The Helicinidæ.

3. J. J. LISTER, M.A., F.R.S., F.Z.S.

On the Distribution in the Pacific of the Avian Family Megapodidæ.

The following papers have been received :—

1. H. W. MARETT TIMS, M.D., F.Z.S., and A. HOPEWELL SMITH,

L.R.C.P.

Tooth-Germs in a Kangaroo.

2. R. BROOM, M.D., D.Sc., C.M.Z.S.

On the Structure of the Skull in Cynodont Reptiles.

3. The Rev. A. MILES MOSS, M.A., F.Z.S., F.E.S.

On the Sphingidæ of Peru. With a Preface by KARL JORDAN, Ph.D.

4. C. E. HELLMAYR, M.B.O.U.

A Contribution to the Ornithology of Western Colombia.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.

May 2nd, 1911.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

May 9th, 1911.

E. G. B. MEADE-WALDO, Esq., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

Mr. R. I. Pocock, F.R.S., F.L.S., Superintendent of the Gardens, exhibited some of the hair of the "puppy coat" of a Grey Seal (*Halichoerus grypus*), which was caught at Barmouth, in Merioneth, at the end of April. When received at the Gardens at the beginning of May this Seal was covered, with exception of the head and flippers, with longish woolly white hair, the last of which was moulted on May 7th. Most authorities state that Grey Seals are born in the autumn, not later than about the middle of October, and that the puppy coat is shed from a month to six weeks later. Allowing six weeks for the retention of its puppy coat, this Welsh Grey Seal must have been born near the middle of March, a date in tolerably close agreement with the date, namely the end of February, given by Cneiff for the birth of these Seals in the Gulf of Bothnia. It is, therefore, quite clear that these Seals breed both in the early spring and the autumn.

Mr. E. G. BOULENGER exhibited some living male specimens of the Midwife Toad (*Alytes obstetricans*) carrying the eggs. He also exhibited a number of the detached eggs to show the manner in which they were strung together.

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Mr. A. E. ANDERSON exhibited a large number of photographs of the more important fossil mammals in the Department of Vertebrate Palaeontology of the American Museum of Natural History, New York, showing the methods of mounting fossil skeletons. For comparison, a set of photographs was exhibited with the skeleton supports eliminated from view, thus adding to the pictorial value of pose in the specimens.

Dr. P. CHALMERS MITCHELL, F.R.S., Secretary of the Society, gave an account, in the absence of the author, of a Memoir by Lt.-Col. NEVILLE MANDERS, R.A.M.C., F.Z.S., on the phenomena of Mimicry amongst Butterflies in Bourbon, Mauritius, and Ceylon. The author had investigated the habits by observation and experiment of the insectivorous reptiles and birds of these islands, and had been unable to accept the view that their relations to butterflies were such as to be effective in producing Batesian or Müllerian mimicry.

Mr. R. I. POCKOCK, F.R.S., F.L.S., read a paper on the Palatability of some British Insects, with Notes on the significance of Mimetic resemblances, and said that at Prof. Poulton's request he had undertaken in the summers of 1909 and 1910 to make a series of experiments in the Gardens to test the edibility of various British insects, most of which were sent to him, together with some slugs, by Dr. G. B. Longstaff. The insects comprised Lepidoptera, Coleoptera, Orthoptera, Hemiptera, Diptera, and Hymenoptera; and the most interesting of the experiments were those made with the Bumble-Bee (*Bombus*) and its mimetic fly (*Volucella bombylans*) to test the theory of mimicry. The *Bombus* proved to be unpalatable to nearly all birds. The birds would try them a varying number of times. When they had learnt their distastefulness by experience they refused to touch them, and then when offered the *Volucella* refused that likewise. A considerable number of species of insectivorous birds were tested in this way, and always with the same result; and the one specimen of *Volucella bombylans* that did duty for some thirty or forty experiments went through the ordeal untouched.

Prof. G. C. BOURNE, M.A., D.Sc., F.R.S., read the second portion of his paper on the Morphology of the group Neritoidea of the Aspidobranch Gastropods, which dealt with the Helicinidae. He stated that this family was capable, by some unknown means, of wide dispersal across seas and oceans, and that the conditions most suitable to its existence were found in proximity to the sea. In describing the anatomy the genus *Alcadia* was taken as the type, and the differences between it and the other genera were pointed out, but the species and even the genera of Helicinidae were closely similar, anatomically, from whatever part of the world they came.

Mr. J. J. LISTER, M.A., F.R.S., F.Z.S., presented a paper entitled "On the Distribution in the Pacific of the Avian Family Megapodidæ."

The next Meeting of the Society for Scientific Business will be held on Tuesday, May 23rd, 1911, at half-past Eight o'clock P.M., when the following communications will be made:—

1. J. STUART THOMSON, Ph.D.

The Alcyonaria of the Cape of Good Hope and Natal.

2. H. W. MARETT TINS, M.D., F.Z.S., and A. HOPEWELL SMITH,
L.R.C.P.

Tooth-Germs in a Kangaroo.

3. R. BROOM, M.D., D.Sc., C.M.Z.S.

On the Structure of the Skull in Cynodont Reptiles.

4. The Rev. A. MILES MOSS, M.A., F.Z.S., F.E.S.

On the Sphingidæ of Peru. With a Preface by KARL JORDAN, Ph.D.

The following papers have been received:—

1. C. E. HELLMAYR.

A Contribution to the Ornithology of Western Colombia.

2. The Hon. PAUL A. METHUEN, F.Z.S.

On an Amphipod from the Transvaal.

3. R. LYDEKKER.

The Somali Rhinoceros and the Nigerian Klipspringer.

Communications intended for the Scientific Meetings should
be addressed to

P. CHALMERS MITCHELL,

Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.
May 16th, 1911.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

May 23rd, 1911.

Dr. A. SMITH WOODWARD, F.R.S., Vice-President,
in the Chair,

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions that had been made to the Society's Menagerie during the month of April 1911.

Prof. ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., communicated a paper by Dr. J. STUART THOMSON on the Alcyonaria of the Cape of Good Hope and Natal. The author dealt exclusively with the order Gorgonacea, and recorded nineteen species, of which six were described as new.

A paper entitled "Tooth-Germs in the Wallaby (*Macropus billiardieri*)," was presented by Dr. A. HOPEWELL SMITH, M.R.C.S., L.R.C.P., and Dr. H. W. MARETT TIMS, M.A., F.Z.S., F.L.S.

The material upon which their observations were based had been kindly sent to the authors by Mr. Brooke Nicholls, of Melbourne. It consisted of three embryos of *Macropus billiardieri*. The smallest specimen (allowing for the difference in size of the adults of different species) was considerably younger than that of any other Diprotodont previously examined. In the upper jaw they had identified six incisors, thus confirming M. F. Woodward's original statement. The functional incisors of the adult appeared to be the 2nd, 4th, and 6th of the series. There were four

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premolars, of which the 1st, 3rd, and 4th persisted. There was also one molar tooth.

In the lower jaw, owing to the difficulty of interpreting the conditions, it was not certain whether there were representatives of five or six teeth in front of the premolars. Presuming there were five, the large functional incisor of the adult was the 4th of the series. As in the upper jaw, there were four premolars and one molar, the 2nd premolar not fully developing. There were evidences of vestigial predecessors to the large lower incisor and to pm⁴.

The following points of histological interest were noted:—

1. The heaping up of the epithelium along the alveolar margins, a character often supposed to be peculiar to the Ungulates.
2. The precocious development of the enamel.
3. The compactness of the stellate reticulum of the enamel-organ.
4. The abundant evidence of blood-vessels within the enamel-organ, thus confirming the observations of Poulton and Howes in the Rodents. The opposite opinion is usually held.
5. Some slight evidence in support of the fusion of enamel-organs. Such fusion has been recorded in the fishes and reptiles, but not hitherto in mammals.

The Rev. A. MILES MOSS, M.A., F.Z.S., F.E.S., gave a short account of his memoir on the Sphingidæ of Peru, based on studies of Lepidoptera, with special reference to the larvæ, which he had made during a three years' residence at Lima. Dr. Karl Jordan had assisted him with the working out of his collections, and had described the following new species of Sphingidæ:—

PROTOPARCE MOSSI Jord., sp. n.

Similar to *P. sexta cæstri* Blanch. (1854). Both wings narrower and more pointed. Fore wing without black streaks on the disc. Antenna thinner. Genitalia quite different, approaching those of *P. hannibal* Cr. (1779).

This paper will be published in the 'Transactions' in due course.

Prof. J. P. HILL, D.Sc., communicated a paper by Dr. R. BROOM, C.M.Z.S., on the Structure of the Skull in Cynodont Reptiles. The author, after a study of all the available material contained in the British and South African Museums, gave a detailed comparative account, illustrated by a series of figures, of the morphology of the skull in the chief genera of the Cynodontia, including *Bauria*, *Nythosaurus*, *Cynognathus*, *Trirachodon*, *Gomphognathus*, *Diademodon*, *Sesamodon*, and *Melinodon*. He also discussed in some detail certain peculiarities of the Mammalian skull, apparently derived from a Cynodont ancestor.

Dr. C. W. ANDREWS, F.R.S., F.Z.S., read a paper "On a New Species of *Dinotherium* from British East Africa." The specimens described were sent to the British Museum by Mr. C. W. Hobley, Commissioner of Mines for British East Africa. They included portions of the mandible with teeth, a calcaneum, and a patella of a small species of *Dinotherium* nearly allied to *D. cuvieri*, from the Lower and perhaps Middle Miocene beds of France. The new species, which he proposed to call *Dinotherium hobleyi*, differed from *D. cuvieri* in several particulars—*e.g.*, the inner anterior column of pm 3 was more distinctly developed, and the talon of m₃ had a distinct tubercle on its inner side. Remains of Rhinoceros, a giant Tortoise, *Trionyx*, and Crocodiles also occurred. The bones were well preserved in a tough clay, and further collecting would no doubt yield important results.

The next Meeting of the Society for Scientific Business will be held on Tuesday, June 13th, 1911, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Dr. R. E. DRAKE-BROCKMAN, F.Z.S.

On Antelopes of the Genera *Madoqua* and *Rhynchotragus* from Somaliland.

2. The Hon. PAUL A. METHUEN, F.Z.S.

On an Amphipod from the Transvaal.

3. R. LYDEKKER.

The Somali Rhinoceros and the Nigerian Klipspringer.

4. C. E. HELLMAYR.

A Contribution to the Ornithology of Western Colombia.

5. Prof. ANGEL CABRERA, C.M.Z.S.

The Subspecies of the Spanish Ibex.

The following papers have been received :—

1. MISS RUTH HARRISON.

Some Madreporaria from the Persian Gulf. With Notes on the Memoir and some Further Notes on *Pyrophyllia inflata* by SYDNEY J. HICKSON, M.A., D.Sc., F.R.S., F.Z.S.

2. CHARLES L. BOULENGER, M.A., F.Z.S.

On Variation in the Medusa of *Merisia lyonsi*.

3. FRANK E. BEDDARD, M.A., F.R.S., F.Z.S.

Contributions to the Anatomy and Systematic Arrangement of the Cestoidea.—No. 2. On Two New Genera of Cestodes from Mammals.

4. R. BROOM, D.Sc., C.M.Z.S.

On some new South African Permian Reptiles.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.
May 30th, 1911.

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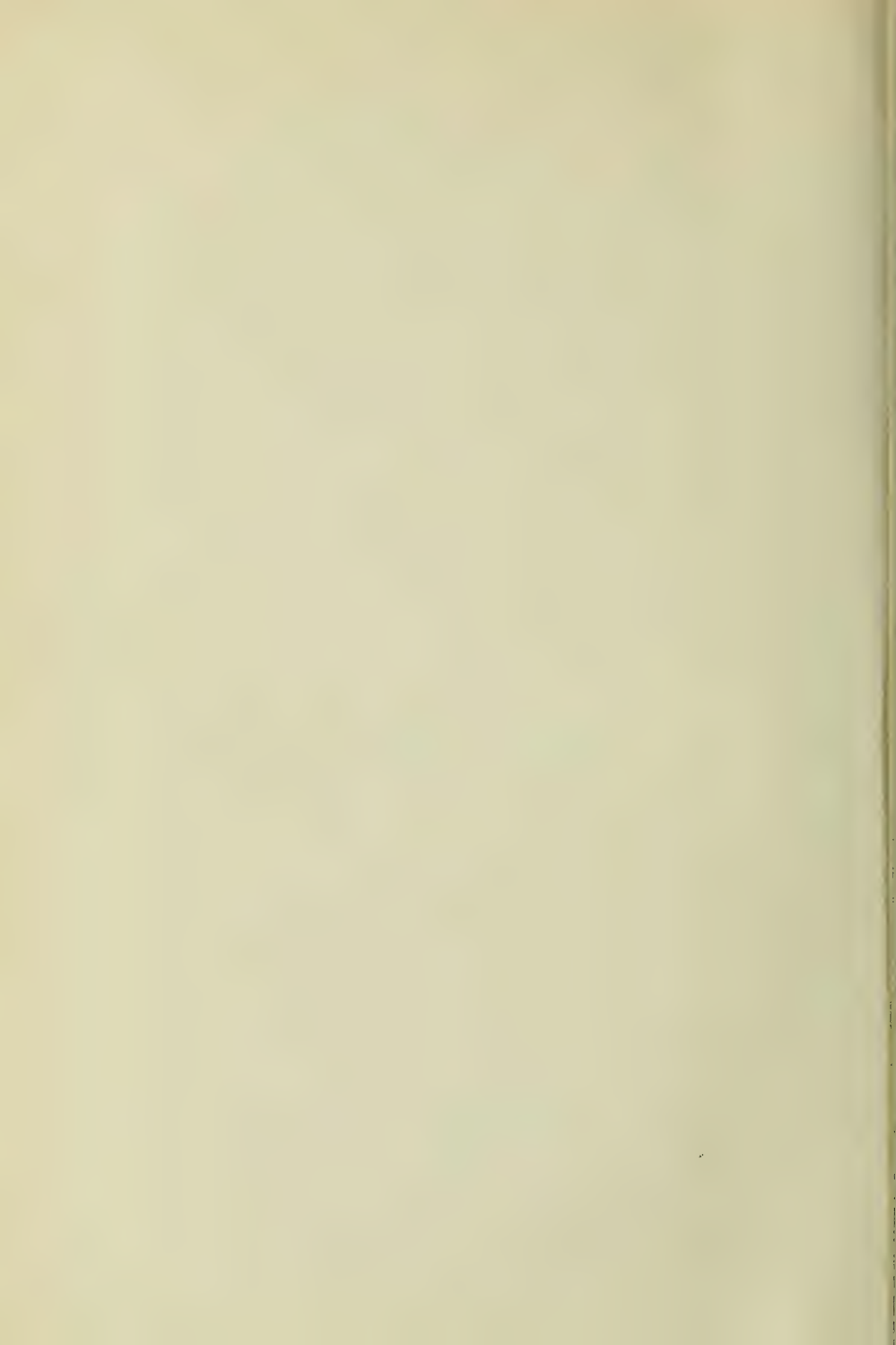
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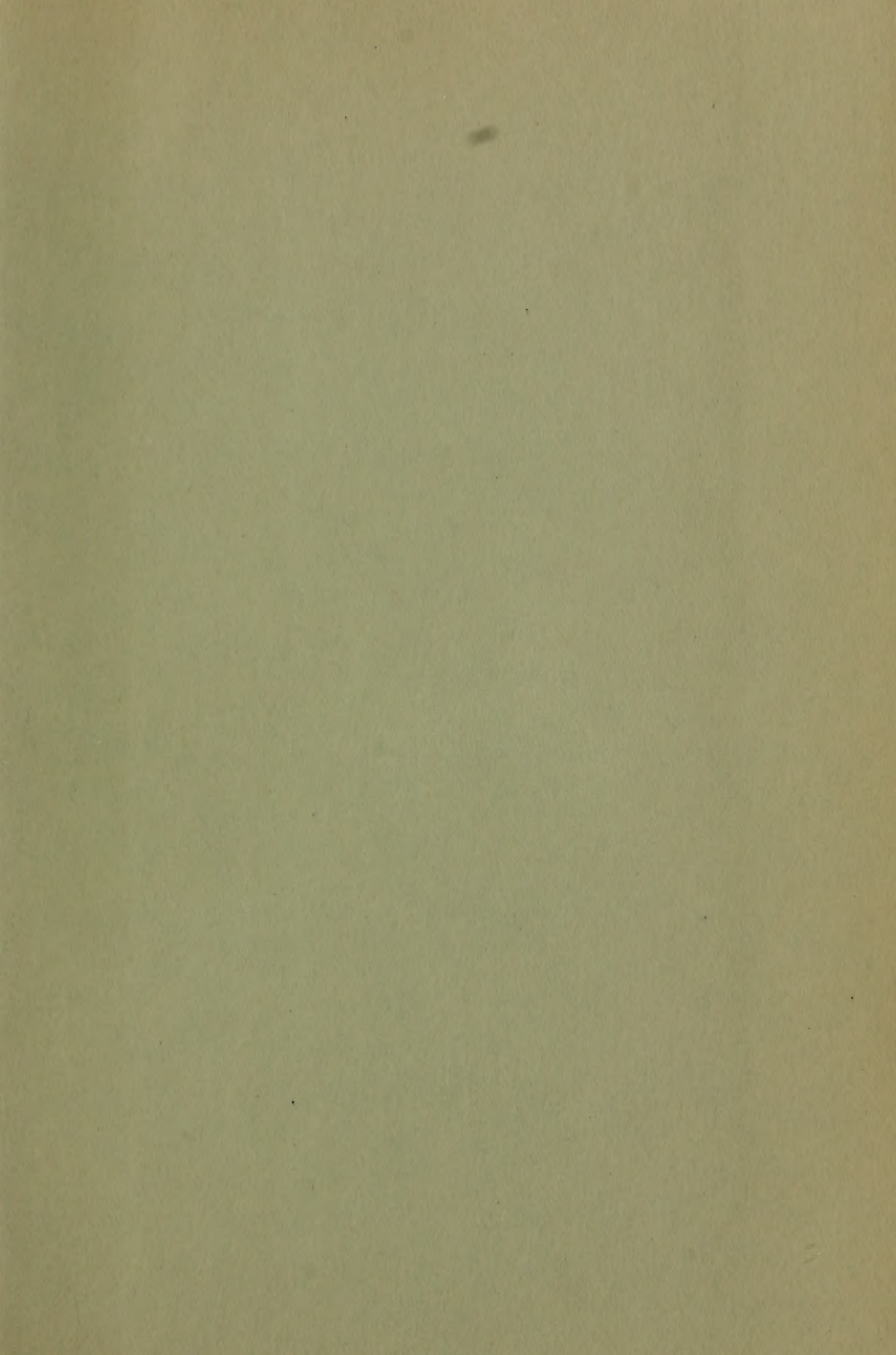
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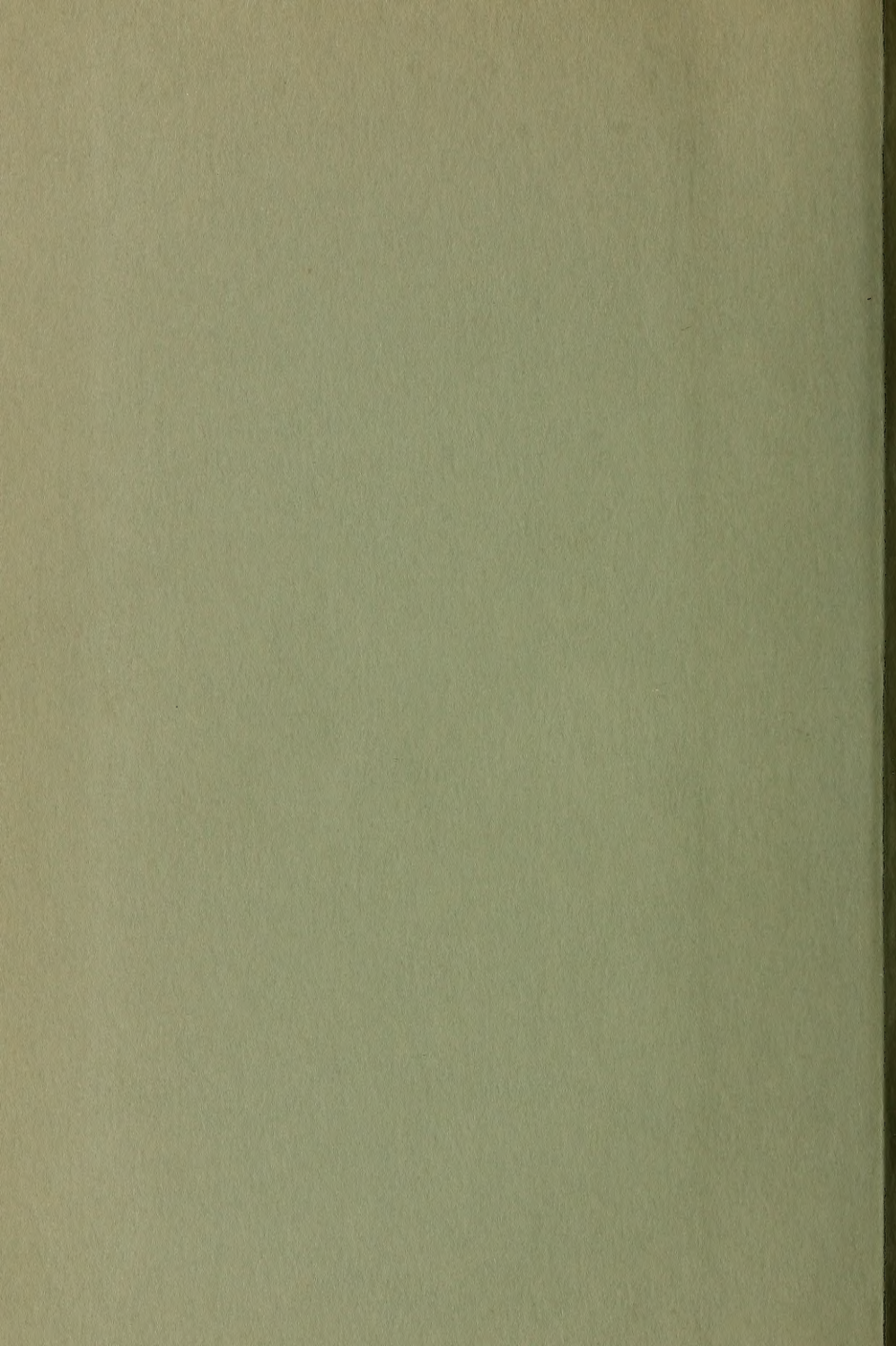
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